N.A.A.S.

Quarterly Review

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N.A.A.S.

QUARTERLY REVIEW

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LONDON: HIS MAJESTY'S STATIONERY OFFICE: 1949

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ARTICLES

PHOSPHATE FIXATION

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The term " phosphate fixation " refers to the changes undergone by phosphates added to soils, and is often very loosely used. It can be employed to mean either the conversion of available phosphates into unavailable forms (i.e., to denote a decrease in availability) or the conversion of soluble phosphates into relatively insoluble forms (i.e., to denote a decrease in solubility). The difference, and also confusion, between these definitions arises from the fact that the actual availability of phosphate in soils, which can be measured only by growing a crop, depends on factors other than solubility. For this and other reasons the writer prefers to use the word " fixation " to denote decrease in solubility.

This definition conveys immediately the idea that water-soluble phosphates added to soils literally become fixed. This in turn leads naturally to the concept of restricted penetration of phosphate in soils, which is very important from the practical point of view. Further, the conversion of soluble phosphates into less soluble forms in soils can take place in several ways, and, since the exact mechanism and relative contribution of the different reactions involved are still not fully understood, " fixation " is a convenient non-committal term to cover them.

Fixation and Availability

In that it prevents extensive losses of phosphate in the drainage, fixation is beneficial. The disadvantage lies in the fact that the products are frequently so insoluble that they are for practical purposes unavailable. Lack of penetration of broadcast phosphate into the root zone can also be a serious difficulty, especially where, as on grassland, there is no incorporation by cultivation. As a result, phosphate may become " positionally " unavailable. On many acid soils treated with phosphate, the extra phosphate recovered in crops before it becomes necessary to add more to maintain yields is equivalent to only about 20 per cent of that applied. If no more were added some of the remainder would gradually be utilized, but at the price of low yields. Recent work, however, throws considerable doubt on the significance of total phosphate recovery values, and there is evidence that they are not a reliable indication of the effect of fixation on the availability of added phosphate. But there is no doubt that much of the phosphate added to acid soils is fixed in unavailable forms. This is shown by the low residual effects of even heavy dressings and by the continual response to, and need for, phosphate. On acid

soils in Aberdeenshire, for example, increases of 20-30 per cent in the yield of turnips have been obtained on applying phosphate to areas which had received 25 cwt. of superphosphate per acre the previous year.

To appreciate the significance of fixation in relation to availability, it should be borne in mind that there is no evidence that plants can take up phosphate in any way other than from solution. Further, it is not only the degree of solubility of the phosphate that is important but also the rate at which it dissolves. Consider, for example, an acre of soil weighing 2,000,000 lb. to normal plough depth and containing 25 per cent water with a concentration of one part per million of P_2O_5, which is higher than is often found. The total phosphate in solution is only $\frac{1}{2}$ lb. of P_2O_5 per acre, and since a normal crop of oats, for example, removes about 20 lb. of P_2O_5 per acre, it is obvious that the phosphate in the soil solution must be replenished continuously. This is particularly important in the early stages of growth, when uptake is rapid.

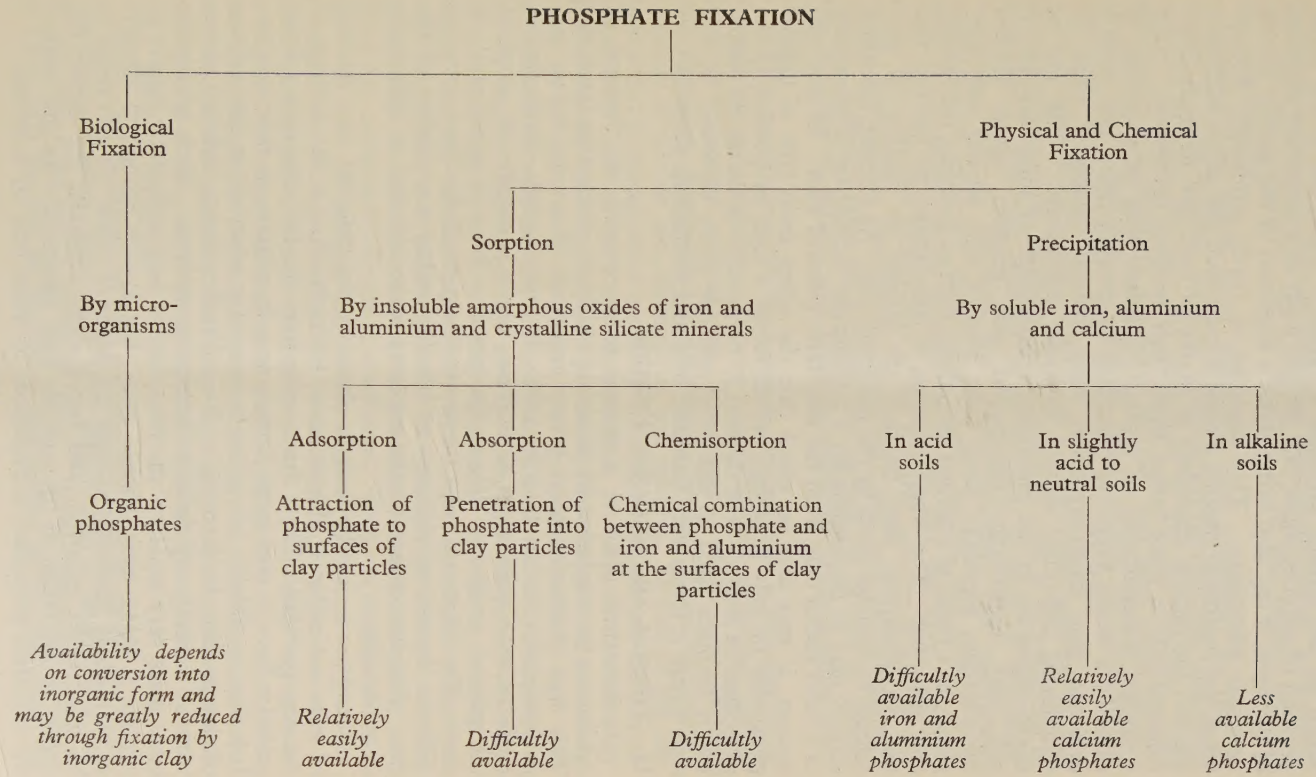
The availability of phosphate in soils is, therefore, determined primarily by the degree of solubility and rate of solution, and may be greatly reduced by fixation. The provision and maintenance of an adequate supply of phosphate in the soil solution, however, is only the first step in the phosphate nutrition of crops. The actual uptake of the phosphate, and hence the availability as measured by the effect on the yield and composition of crop, depends on many other factors, such as aeration and the supply and balance of other nutrients, consideration of which is outside the scope of this article. It should also be remembered that the decrease in solubility during fixation is not of necessity accompanied by a comparable decrease in availability. The concentration of phosphate in the soil solution necessary for satisfactory growth is very low, and some of the products of fixation are still sufficiently soluble to meet the needs of the crops. It is, therefore, necessary to make a distinction, which is very important from the practical point of view, between "fixation in easily available form" and "fixation in difficultly available form."

The Nature of Fixation

As already indicated, phosphate fixation is not one simple chemical reaction, but a complex process in which several different reactions can take place at the same time. The main reactions possible are summarized in a simplified form in the diagram opposite.

I. Biological Fixation

Up to one half or more of the phosphate present in soils may exist in organic forms. Much of this is probably derived from plant residues, but some of it represents conversion of applied inorganic phosphate into organic form by the soil micro-organisms. This aspect of phosphate fixation has been comparatively little investigated, especially in this country, but it is well established that the addition of readily oxidizable organic matter to soils stimulates the micro-organisms which require phosphate for their nutrition and thereby converts inorganic phosphate into organic form—mainly nucleoproteins


PHOSPHATE FIXATION
Biological Fixation
Physical and Chemical Fixation
Sorption
Precipitation
By micro-organisms
By insoluble amorphous oxides of iron and aluminium and crystalline silicate minerals
By soluble iron, aluminium and calcium
Adsorption
Absorption
Chemisorption
In acid soils
In slightly acid to neutral soils
In alkaline soils
Organic phosphates
Attraction of phosphate to surfaces of clay particles
Penetration of phosphate into clay particles
Chemical combination between phosphate and iron and aluminium at the surfaces of clay particles
Availability depends on conversion into inorganic form and may be greatly reduced through fixation by inorganic clay
Relatively easily available
Difficultly available
Difficultly available
Difficultly available iron and aluminium phosphates
Relatively easily available calcium phosphates
Less available calcium phosphates

which are not directly utilizable by plants. Thus, just as the incorporation of unrotted straw into the soil leads to a temporary depletion of nitrogen, it can also bring about a depletion of the readily soluble inorganic phosphate. This depletion is partly temporary, because when the oxidizable organic matter is exhausted the micro-organisms die and the organic phosphate is converted back into inorganic form (mineralized) to some extent when their residues decompose. Such a gradual mineralization of organic phosphate may be important in ensuring a steady supply of phosphate to growing crops, and there is evidence that micro-organisms have another beneficial effect in solubilizing difficultly soluble inorganic phosphates. The role of micro-organisms in the phosphate relationships of soils, however, is still very imperfectly understood and requires much further investigation, especially since their number and activity may vary greatly as a result of common operations, such as draining, cultivating, and manuring. The whole question is complicated by the fact that the nucleoproteins they produce are subject to fixation in very difficultly available form by the inorganic clay. As a result, microbial activity may be responsible for a considerable locking-up of phosphate in a form useful only from the long-term point of view. In this connection, it may also be noted that the other main type of organic phosphate in soils is phytin, which forms a high proportion of the phosphate in seeds. It is claimed to be directly utilizable by plants, but it becomes fixed in difficultly available form, especially in acid soils where it forms very insoluble iron and aluminium phytates.

II. Physical and Chemical Fixation

(*a*) Sorption. This is a general term covering the removal of substances from solution by materials which are themselves insoluble. This type of reaction plays a very important, if not the major, part in phosphate fixation in acid soils. In the diagram, distinction is made between three types of sorption, but it is outside the scope of the present article to discuss the physico-chemical significance of these. The important point for present purposes is that they represent different degrees of tightness of binding and/or accessibility of the fixed phosphate which can be expected to be reflected as differences in availability.

Adsorption is largely brought about by the colloidal clay fraction of soils and is due to the attractive forces residing at the surfaces of the clay particles. These forces arise from the fact that such minute particles have a very large surface area in relation to their volume. It is thus possible for phosphate to be held or adsorbed on the surfaces of clay particles by forces of a physical rather than a chemical nature without forming any definite chemical compound. Such adsorption takes place very rapidly ; the phosphate is held sufficiently tightly to prevent it being easily washed away, but loosely enough to allow it to be released gradually to meet the needs of crops. It also tends to be more easily removed, and hence more available, the higher the degree of saturation of the surfaces with phosphate. In this respect the adsorbed phosphate is analogous to water held by a sponge.

Absorption implies penetration of the phosphate into the internal structure of the clay particles and takes place more slowly. In general, the absorbed phosphate can be expected to be less readily released and less available.

Chemisorption differs from absorption and adsorption in that it implies a more specific chemical combination between the phosphate and, for example, the iron and aluminium in the clay particles. Like adsorption it is primarily a surface reaction and takes place rapidly. Depending on the type of chemical bond formed, the chemisorbed phosphate can be tightly held and difficultly available.

In practice, the relative contribution of adsorption, absorption, and chemisorption to the sorption of phosphate by soils is very difficult to determine. The clay consists of an intimate mixture of crystalline minerals, such as kaolinite and montmorillonite, and amorphous complexes of iron and aluminium oxides, humus, and silica. Both these components, which probably grade one into the other, can sorb phosphate, but the greater part of the sorptive capacity of soils is due to the amorphous complexes, particularly the iron and aluminium oxides. Sorption takes place extensively up to a *p*H of over 6. Above this it decreases rapidly and becomes negligible under alkaline conditions.

(*b*) PRECIPITATION. Unlike sorption, precipitation is brought about by substances in solution. In soils, phosphate is precipitated mainly by iron, aluminium, and calcium. The extent to which these different phosphates are precipitated is determined by the *p*H and the relative amounts of soluble iron, aluminium, and calcium. In soils of *p*H less than about 6, precipitation is mainly in the form of iron and aluminium phosphates because they are least soluble, and hence most readily formed under acid conditions. In the freshly precipitated state they may be of some value to plants, but generally speaking iron and aluminium phosphates are difficultly available. At or a little below *p*H 6, i.e., in slightly acid to neutral soils, precipitation of calcium phosphates begins, and it is very important to note in relation to liming that the calcium phosphates formed in this acidity range are relatively available to plants. In alkaline soils precipitation of calcium phosphates is even more extensive, but they are more insoluble and difficultly available under these conditions. There is strong evidence that the role of calcium in phosphate fixation is not confined to precipitation, because its effect can be detected at *p*H values as low as 4 where precipitation does not normally occur. The probable explanation is that the exchangeable calcium acts as a link between the soil colloids and the phosphate. Since phosphate fixed in this manner can also be expected to be relatively available, this effect adds to the practical importance of calcium in the phosphate relationships of soils.

III. RATE OF FIXATION

When a soil is shaken up with a phosphate solution under laboratory conditions, fixation takes place very rapidly and is generally about 90 per cent complete in about an hour. If the phosphate is added in solid form the rate of fixation is determined in the first place by

the rate at which it dissolves, and water-soluble phosphates, such as superphosphate and ammonium phosphate, are fixed more rapidly than water-insoluble forms, such as dicalcium phosphate, which dissolve more slowly in the soil solution. Very insoluble forms, such as mineral phosphates, can be expected to remain as such for long periods. The time necessary for more or less complete fixation to take place under field conditions is difficult to establish with certainty, but solubility measurements suggested that in one type of acid Scottish soil containing about 20 per cent moisture, ordinary superphosphate was extensively fixed in about one week and basic slag in about six weeks.

IV. Redistribution and Ageing of Fixed Phosphate

Following the initial rapid fixation, the fixed phosphate can undergo further physical and chemical changes leading to still lower solubility and availability. These secondary changes take place slowly and are difficult to prove, but there is little doubt that they occur, and they are probably important in determining the residual effects of phosphate fertilizers. One possible type of change which can take place is a redistribution of the fixed phosphate in which, for example, adsorbed phosphate becomes absorbed or chemisorbed, or in which precipitated calcium phosphates become converted into very insoluble and difficultly available apatites. The other general change which can occur is ageing, which takes place, for example, as a result of drying and alters the physical condition of the phosphate, again making it less soluble and available.

V. Effect of Other Fertilizers on Phosphate Fixation

Evidence is accumulating that salts such as sulphate of ammonia and muriate of potash can increase the capacity of soils to fix phosphate. This is certainly true under laboratory conditions, and it operates extensively at *p*H values prevailing in soils. But the mechanism of the effect and its significance in relation to phosphate availability are not yet clear, and its importance under normal practical conditions remains to be established.

Reducing Fixation in Difficultly Available Form and increasing the Efficiency of Phosphate Fertilizers

There are four main approaches to this problem :

I. Improving Soil Conditions

Apart from maintaining general fertility, this means liming acid soils and conserving organic matter.

(*a*) Liming. Adequate liming is indispensable for the efficient use of phosphate fertilizers. It reduces fixation in difficultly available forms by iron and aluminium by increasing the *p*H, and causes formation of relatively available calcium phosphates. At the same time it helps to reduce the general fixation by the clay by causing the individual particles to form aggregates, i.e., to flocculate. It also tends

to promote the decomposition and release of organic phosphate. There is plenty of evidence from field experiments that liming markedly improves the efficiency of applied phosphate, especially water-soluble forms. For maximum effectiveness the lime should be thoroughly incorporated and allowed to react with the soil before the phosphate is applied. A *p*H of about 6.5 is probably about the optimum level to which to lime, but in general it may be taken that if the *p*H is between 6 and 7 the conditions are favourable. This applies not only to minimizing fixation in difficultly available form and promoting fixation in easily available form, but also to facilitating the actual uptake of phosphate by the plants, which takes place most readily under slightly acid conditions. Under alkaline conditions more difficultly available calcium phosphates are formed, and the alkalinity interferes with the uptake of phosphate. Liming to *p*H values considerably above 7 is, therefore, to be avoided and the best liming policy is to bring the soil to a *p*H of about 6.5 and maintain it there.

(*b*) Conserving Organic Matter. The organic matter of soils, which has itself little capacity to fix phosphate, can reduce fixation by iron and aluminium compounds by combining chemically with them and by physically coating them, thereby hindering access of the phosphate. But, as already indicated, the addition of organic matter produces complex changes in the soil phosphates through the agency of the micro-organisms which decompose it. It is impossible to generalize about these changes, some of which are not beneficial from the short-term point of view, but there is no doubt that the net long-term effect of organic manuring is to promote better utilization of applied phosphate.

II. Altering the Chemical or Physical Form of the Applied Phosphate

(*a*) Water-insoluble Forms. These include a range of compounds from the very insoluble mineral phosphates to the comparatively soluble di- and tri-calcium phosphates which are formed, for example, by reverting ordinary superphosphate with limestone or serpentine. Although normally regarded as water-insoluble, these materials dissolve at varying rates in the acid or slightly acid soil solution and are slowly fixed. Provided they dissolve rapidly enough to meet the needs of the crop, they might be expected to give it a better chance of competing with the soil and to be more effective than water-soluble forms. Many field and pot experiments have therefore been carried out to test the effectiveness of various insoluble phosphates. Space precludes any comprehensive review of these experiments here, but most of the Scottish and some of the English results have been published [1, 2]. It is, of course, dangerous to generalize, but the results suggest that superphosphate is not easily surpassed and that no major increase in the efficiency of applied phosphate is likely from the use of materials such as bone phosphates, reverted phosphates, or high temperature phosphates. The choice, if any, must be made on the basis of local experience.

(*b*) Granular Phosphates. The possibility of increasing the efficiency of superphosphate by applying it in granular form has received considerable attention abroad and has often proved effective. Experiments are in progress in this country and more are planned. Scottish experiments have shown no significant difference in effectiveness between ordinary and granular triple superphosphate, but the granules used were only about 3/16-inch in diameter and tests are being made with larger granules. Since granulation is normally associated with water-soluble forms, it is interesting to note that granular steamed bones proved at least as effective as steamed bone flour. This is of interest because granular products are much more convenient to handle, and the case for granulation does not rest entirely on increasing efficiency. Final assessment of the effectiveness of granulation as a means of increasing the efficiency of phosphate fertilizers under British conditions must, however, await the results of more experiments. For the present it can be said that granular forms are at least as effective as powdered forms.

(*c*) Dung-Superphosphate Mixtures. Recent experiments in Sweden and America indicate that the efficiency of superphosphate can be increased considerably by mixing it with dung before applying it to the soil. Its use in this way to reduce the loss of ammonia from dung has, of course, been known for a long time. The superphosphate in such mixtures is subject to reversion into dicalcium phosphate and to considerable physical protection from the soil, and the improvement may be due largely to decreased fixation for these reasons. But the formation of organic phosphates, such as carbohydrate phosphates, by microbial action may also be an important factor. In any case, the admixture of superphosphate with dung warrants further investigation from the phosphate point of view, and experiments are being started at the Macaulay Institute.

III. Placement of Phosphate

Fixation takes place most rapidly when phosphate is broadcast and distributed through the whole mass of soil. From this point of view broadcasting is an inefficient method of application, and a great deal of work has been done on methods for placing phosphate in relatively concentrated layers, either directly with the seed or in the root zone. It is now well known that such placement produces marked increases in the efficiency of applied phosphate under British conditions, and in the case of cereals, for example, a half dressing combine-drilled with the seed is as effective as the full dressing broadcast [3, 4]. Many aspects of placement, such as the best placement for different crops and the effect of fertilizer mixtures, are still under investigation. It probably involves factors other than a mere reduction in fixation, but of its efficiency as a means for increasing the efficiency of applied phosphate there is no doubt.

IV. Adjusting Rate and Frequency of Application

In acid soils with high fixation capacities the direct residual effects of normal dressings of phosphate are generally small and often negligible.

Further, even with sensitive crops, such as roots, on very deficient soils, there is generally little further increase in yield obtained from dressings higher than about 1 cwt. of P_2O_5 per acre. On such soils, therefore, it is uneconomical to apply dressings greatly in excess of this amount at any one time, and applications to individual crops are much more efficient than one or two heavy applications during the rotation. Indeed, it is probably true for the great majority of soils that a given quantity of phosphate is much more efficiently used when divided into dressings for successive crops than when applied all at once to one crop. Further, since crops vary in their response to phosphate the quantity used for each crop should be adjusted accordingly. It should also be borne in mind that crops vary in their ability to draw on difficultly available forms of phosphate, the typical example being potatoes for which slowly available phosphates such as mineral phosphates are of little use. There is no doubt that by applying these principles in the light of local experience the losses due to fixation can be reduced considerably.

Conclusion

In the space available it has not been possible to touch upon all aspects of phosphate fixation; for example, it can take place during extraction of soils with weak acid solutions for the purpose of assessing phosphate requirements, and it complicates greatly the interpretation of the values obtained. Our knowledge is still very incomplete in many respects, and in practice it is difficult to determine with any certainty the relative contribution of the different types of fixation and to distinguish, for example, between chemisorption and precipitation. The main point from the practical point of view is that fixation in difficultly available form is least in the region of *p*H 6.5. Apart from applying phosphate to individual crops in accordance with their responsiveness, the chief measures at present available for increasing the efficiency of phosphate fertilizers under British conditions are suitable placement and adequate liming.

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EXPERIMENTAL FARMS: THEIR PURPOSE AND FUNCTION

1. EXPERIMENTAL HUSBANDRY FARMS

J. A. McMillan

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The raising of production in volume and quality, with due regard to economic considerations, usually results when some valuable variation from normal farming practice is adopted. It is clearly desirable that any such variations should be brought to light and tested on a commercial scale, so that if suitable they may be incorporated as widely and as quickly as possible into farming systems. In the past, old but long-forgotten practices have sometimes been re-discovered and become useful aids to better farming, following such modifications as were necessary to meet modern conditions. New and far-reaching improvements, too, have been introduced by progressive farmers as the result of keen and critical observation and tests on their own farms, and have gradually been adopted by their neighbours.

Though the more important changes in practice have followed the findings of pioneers, it is true that many farmers naturally develop a sense of acute observation and frequently lay down simple trials to provide guidance in some aspect of the management of their farms. One knows that "live" demonstrations at agricultural shows or arranged in connection with farm walks do exert a considerable and beneficial effect and often lead to the wider use of better varieties or the introduction of better methods.

Valuable assistance has also been given by farmers in laying down experiments in association with research station and county staffs. These experiments have given useful information on a variety of soils and under varying climatic conditions, and have proved helpful guides both to the farmers and their advisers.

While it is hoped that such activities will be continued—and indeed expanded—in certain directions, there is an obvious need for the provision of centres where more critical work can be undertaken. Commercial farms are not well suited to really long-term or critical experiments, where constant observation is necessary, or for trials of different systems of cropping and livestock breeding.

Location

The long-felt need for definite Experimental Husbandry Farms was accentuated by the setting-up of the National Agricultural Advisory Service, whose officers (as well as those of the research stations) need greater facilities to tackle many problems now awaiting solution. A paper presented to the Agricultural Improvement Council in 1944 by the late Sir John Fryer on the need for a national chain of experimental farms on a system of husbandry basis was most opportune, and, as the result of subsequent discussion, the Experimental Husbandry Farms Committee obtained the Council's support in 1945 for the

proposal to set up a number of farms—a proposal which was later accepted by the Ministry. Particulars relating to these farms, along with certain other proposals that have since been made, are given in the Table below:

Proposed Location of Experimental Husbandry Farms and Notes as to Present Position

No.	Soil Type and Climate	County	Province	Proposed Minimum Acreage	Farm Acquired or Leased	Actual Acreage
1	Clay, low rainfall	Cambs	E.	350–400	Cuckoo Pastures, Boxworth	840
2	Clay, low rainfall	Warwicks	W.M.	350–400	—	—
3	Sands	Notts	E.M.	400–500	Gleadthorpe Grange, Warsop	493
4	Chalk	Hants	S.E.	600–800	Bridget's Farm, Martyr	1,035
5	Chalk	Originally Lincs, now Yorks	Y. & L.	500	Negotiations proceeding	—
6	Oolitic limestone	Glos	S.W.	500	—	—
7	Clay, high rainfall	Somerset	S.W.	250–300	—	—
8	Cultivable uplands, north	Northumberland	N.	700–800	—	—
9	Cultivable uplands, west and s-west	Cardigan	Wales	200	Trawscoed, near Aberystwyth	1,000
10	Cultivable uplands, west and s-west	Devon	S.W.	100	—	—
11	Hill land (Wales)	Caernarvon	Wales	To take 1,000 breeding ewes	Negotiations proceeding	—
12	Hill land (north)	Border country	—	do.	Sourhope Farm, Roxburghshire*	—

* Under the Scottish Hill Farm Research Committee (see p. 158). *(contd.)*

Proposed Location of Experimental Husbandry Farms and Notes as to Present Position *(Contd.)*

No.	Soil Type and Climate	County	Province	Proposed Minimum Acreage	Farm Acquired or Leased	Actual Acreage
13	Lighter arable lands, eastern counties	Norfolk	E.	400	Discussions in progress *re* an arrangement with the Norfolk Agricultural Station, Sprowston	—
14	Black fens	—	—	—	This case is being specially investigated (See later)	—
15	Silt and brick earth	Norfolk or Lincs (Holland)	E.	—	Terrington St. Clement, King's Lynn Kirton, Boston	200 105
16	Medium to heavy loams, lower rainfall	Shropshire	W.M.	400	—	—
17	Better arable land, north	Yorks	Y. & L.	400	—	—
18	E. Lancs	Lancs	Y. & L.	200	—	—

Four farms have now been acquired—No. 3, 4, 9 and 15. The two at Terrington St. Clement and Kirton (No. 15) will be regarded as one unit, with a single Farm Director stationed at Terrington St. Clement and a horticulturist, as his senior assistant, at Kirton. The Terrington farm will be concerned with potatoes as one of the leading crops for experimental work, whilst at Kirton particular attention will be devoted to work on bulbs and vegetable crops. Sourhope Farm, Roxburghshire (No. 12) is under the aegis of the Scottish Hill Farm Research Committee, but a link with the North of England is maintained by the appointment of three English members to this Committee and by an agreement that the Director of the Northern Province should be consulted on matters of special interest to the North of England.

Discussions have been held to determine whether arrangements can be made to allow of the Norfolk Agricultural Station, Sprowston (No. 13), being regarded as one of the chain of national farms in so

far as it might undertake certain experimental work on an agreed plan. A long lease has been taken of Cuckoo Pastures Farm, Boxworth (No. 1), and negotiations are in progress for farms No. 5 and 11. It was considered it would be difficult to select one fenland farm to investigate satisfactorily the many fen problems, on account of the variability of soils in that area. The proposal in regard to No. 14, therefore, is that a few small areas, representing different soil types, should be selected and brought under the control of one of the main farms. The proposal to have a farm at East Lancs (No. 18) was accepted only recently. It is hoped to establish there a farm representative of a very wide area where the restriction of supplies of imported feeding-stuffs has created a number of serious technical and economic problems.

Administration

A Director will be in charge of each farm. He will be responsible for the day-to-day management, and will have a small number of technical officers to assist him in ensuring that the experimental work approved for his farm is being carried out satisfactorily. He will need to keep in contact with other technical officers who, as individuals or groups, have a direct interest in any of the experimental work in progress on the farm.

A local Farm Advisory Committee will be set up for each farm, consisting of a chairman, three farmers, the Provincial Director, one specialist officer of the province, the County Agricultural Officer, two representatives of universities or research stations, and one of the Agricultural Land Service. The Provincial Director will be the vice-chairman.

Allotment of Experiments

There will clearly be a limit to the amount of critical experimental work that can be undertaken on the Experimental Husbandry Farms. Requests are likely to be numerous and varied, and it was considered necessary, therefore, to set up machinery to deal with the allotment of experiments and so ensure an order of priority. The Ministry has now agreed that the Agricultural Improvement Council, through its Experimental Husbandry Committee, should advise upon all requests and make recommendations as to the work to be undertaken on each farm. The committee's constitution is a chairman, three members from the N.A.A.S., three from the A.R.C., and three from the A.I.C. It will have the assistance of two sub-committees—one to deal with crops, the other livestock.

Requests for facilities for experimental work will come from a number of sources, e.g., research stations, provincial Experiments Committees, conferences of specialist officers, the Farm Directors, the local Farm Advisory Committees, and other bodies. In order that all proposals can be reviewed periodically, it has been agreed that those relating to work scheduled to begin in the autumn should be received not later than May 1 and those for work beginning in spring by November 1. The Experimental Husbandry Committee may, however, be called upon to advise on issues wider than recommendations

for short-term experimental work, part of which it may consider should be conducted on private farms rather than on Experimental Husbandry Farms. The acquisition of new farms, the co-ordination of the work between the various farms, the planning of large-scale husbandry experiments, the particular breeds which should be kept and the breeding policy which should be adopted are some of the many matters upon which guidance may be sought.

It is a first essential that the Experimental Husbandry Farms should be so well farmed as to focus the attention of those farming on the particular soil types and systems of husbandry which they represent, quite apart from any interest that will arise from the experimental work in progress. In a number of cases, Farm Directors will have to concentrate during the first year or two on cleaning the land and arranging for the necessary repair and adaptation of the farm buildings and cottages. Some farms will need certain new buildings ; their construction will involve much careful thought and planning, for they will not only serve the farms as commercial units but may have to be adapted for certain experimental work of a long-term character. It is, however, desirable that as far as is possible the design should allow modification for a variety of purposes, and considerable use is likely to be made of the M.A.F. buildings.

All types of livestock will not be represented on each farm. The general policy will be to select two or three types for each farm and to build up large breeding units. For example, one farm might carry a large dairy herd and a breeding herd of pigs ; another, beef cattle and poultry ; on a third, sheep might be the major livestock enterprise. Over the whole range of farms, therefore, there might be five or six with large dairy herds of the more important breeds, six or seven with large flocks of sheep, and somewhat similar numbers with large units of beef cattle, pigs and poultry. The breeding policy at each will require careful review in relation to that at the other farms and with long-term fundamental work in view, e.g., alternative methods of improving livestock. It will also have to be devised in close consultation with research stations, with due regard to their work in progress or planned for the immediate future.

This note gives little detail of the individual farms ; it is hoped that short articles on each will appear in this Review from time to time.

The establishment of Experimental Husbandry Farms marks a definitely new and forward step in the effort to provide a link between science and practice. All N.A.A.S. officers should realize the increasingly important role they will play in the solution of major problems under a variety of soil and climatic conditions and the contribution they will make in assisting to build up and maintain a live advisory service. It is hoped that all officers will be ready to make helpful suggestions as to how they may become more effective units in the attainment of these objectives. It is well to remember that some of the more important developments in agriculture have resulted from the following-up of seemingly insignificant observations.

2. EXPERIMENTAL HORTICULTURE STATIONS

C. E. Hudson

Senior Education and Advisory Officer, N.A.A.S.

The desirability has long been recognized of having a number of experimental stations in various parts of the country to test the findings of research stations under different soil and climatic conditions. The stations now proposed will have the staff and facilities for investigating local problems, thus enabling the growers to take a close interest in and maintain contact with recent research. The location has been decided after considering three main factors :

(*a*) Their relation to the site of the research stations ;

(*b*) The need for their proximity to large local centres of production ;

(*c*) The need for planning them so as to cover the main climatic regions in the country.

It is hoped that the existing Horticultural Research Stations will shortly be strengthened by the establishment of a Vegetable Research Station and the expansion on a new site of the Glasshouse Research Station to include investigations on the cultivation of flowers. There will then be two Horticultural Research Stations for investigations concerned mainly with fruit (Long Ashton and East Malling), one for glasshouse crops and flowers, one for vegetables, and the John Innes Horticultural Institution, which is concerned primarily with the genetics of horticultural plants.

It is proposed to set up five experimental stations including, in some cases, sub-stations. Brief details are as follows :

Cornwall. Approximately 100 acres. Concerned primarily with the study of early spring vegetables, flowers and bulbs, such as are produced in Cornwall and the Isles of Scilly. This station will be associated particularly with the Vegetable and Flower Research Stations.

Worcestershire. A station of 150-200 acres for fruit, hops, vegetables, flowers and glasshouse crops. Owing to the difficulty of finding a site suitable for all these crops, it is probable that, for the time being, the proposed sub-station for the Yorkshire station to be situated in Lancashire will be used to serve the requirements of the West Midland area as far as glasshouse crops and cut flower production are concerned.

Yorkshire. 100-150 acres, to be used primarily for work on vegetables, rhubarb, soft fruit and the cultivation of crops under Dutch lights and cloches. A sub-station for glasshouse crops and flowers will be needed in Lancashire, where there is a large area of glasshouses.

East Anglia. A holding of 150-200 acres for fruit, vegetables, glasshouse crops and flowers. Owing to the very different soil conditions in the Isle of Ely and Wisbech districts, it will be necessary to have a small sub-station mainly for investigations on fruit.

Kirton is part of an Experimental Husbandry Farm, but the experimental work on bulbs will be continued and extended and, in addition, some vegetable experiments will be carried out. The glasshouses at Terrington will also be used for experimental work and for investigating local growing problems.

Hampshire. A station of 100-150 acres, mainly for soft fruits, vegetables and glasshouse crops, is planned for the area on the Hampshire-Dorset border.

Fruit Variety Testing Station. A site has been acquired at Mereworth Woods, near East Malling Research Station ; the National Fruit Trials will gradually be transferred here and will then be under the auspices of the N.A.A.S. The Royal Horticultural Society have been asked to continue the trials at Wisley for the time being.

Demonstration Stations. Three Demonstration Stations have been agreed for Wales. One is to be situated in the Cardiff area, mainly for the cultivation of vegetables and crops under Dutch lights and cloches. A small area will be established on the farm at Trawscoed, more particularly for demonstrating the methods of propagating soft fruit ; a third station is to be situated in the Bangor area.

Management and Staff

As the Ministry will have to account to the Treasury and Parliament for the running of the stations, management must rest with the Department ; responsibility will, however, be delegated as fully as possible to the Station Director, who will be an officer of the Department.

All proposals for investigational work at the stations will be considered by a sub-committee of the Agricultural Improvement Council under the chairmanship of Dr. H. V. Taylor, known as the Experimental Horticultural Committee, and will be made the subject of recommendations to the Ministry. The terms of reference of this committee are :

> " To arrange and consider proposals for investigational work on experimental horticulture stations and elsewhere ; to make recommendations to the Ministry as to the work to be undertaken, and as to the allocation of the facilities available at the several experimental horticulture stations, and to report accordingly to the Agricultural Improvement Council ; to advise the Ministry on the suitability of properties for use as experimental horticulture stations ; and to receive and consider periodic reports on the conduct of the investigational work within its purview. The committee to appoint such sub-committees as may be desired."

A sub-committee of the Headquarters Experimental Horticulture Committee has been appointed to integrate the work on bulbs and, in particular, the work at the two stations concerned.

Proposals to the Experimental Horticulture Committee for work will come from four main sources :

(*a*) Provincial Experiments Committee, (*b*) Directors and Local Advisory Committees of experimental stations, (*c*) research stations, through the Agricultural Research Council, and (*d*) other bodies.

It is essential that all experiments should be planned carefully with due regard to securing a measurement of experimental error.

The Experimental Horticulture Stations and the new Fruit Variety Testing Station will come under the N.A.A.S. on similar lines to the Experimental Husbandry Farms. There will be a local Advisory Committee for each station, comprising the Directors of the main research stations or variety testing stations concerned (or their representatives), local growers, and representatives from the N.A.A.S. Normally the chairman of the committee will be chosen from among prominent members of the industry, and the Provincial Director or his Deputy will act as vice-chairman. These Local Advisory Committees will assist the Station Director in the general management of the station and the general conduct of the experimental work, and draw attention to any local problems of particular interest or concern which appear to require investigation.

Each station will have a Director who will be responsible for the management of the station and for the preparation of annual estimates and accounts. He will have specialist assistants and recorders provided by the N.A.A.S. The additional facilities will provide more accurate information for the grower and should also bring him into much closer touch with investigational and research work.

All Experimental Horticulture Stations will come under the general supervision of the Chief Horticulture Officer at Headquarters, to whom Station Directors will be responsible. The Chief Horticulture Officer will be responsible for keeping the Experimental Horticulture Committee informed about the execution of the approved programmes, the progress of the work, and the results of the experiments. It is hoped to make arrangements in due course for the regular publication of the results of work carried out at the stations.

Interim Arrangements

Until it is possible to acquire the land and equip the new stations, a number of small centres have been taken over from the County Councils to enable some investigations to be continued. These plots include two in Cornwall : the one at Gulval is continuing the observation and other plots on bulbs, and also duplicating experiments on bulbs that are being undertaken at Kirton, while the small centre at Ellbridge is devoted almost entirely to observation and demonstration plots.

The centre at Botley (Hampshire) is being used primarily for experiments on " Red Core " disease of strawberries. A small fruit plot in Suffolk at Wickham Market has been continued as a centre for observation plots on fruit.

ABSTRACTS

ANIMAL BREEDING

Pigs

Family Merit and Individual Merit as Basis for Selection. Lush, J. L. *Amer. Nat.*, **81**, 241-61 ; 362-79.

The story begins with the practical problem of deciding how much attention should be paid to the merits or defects of litter mates when choosing boars and gilts for breeding. Selection may be based on :

(*a*) the individual's own phenotypic merit (i.e., mass selection) ;
(*b*) the average merit of the family, where the whole family is selected or rejected as a family ; or
(*c*) a combination of individual merit plus some attention to the average merit of the family.

Mass selection results in choosing some of the same individuals as would be chosen under purely family selections, since the family average can be high only when it has a fair proportion of good individuals. Should selection on either the individual or the family method be completely ineffective, then it would be the same in both cases. A compromise is to select partly on individuality and partly on family average.

The process of selecting correctly consists of predicting the breeding value of each individual, and results depend on the accuracy of this prediction.

Family selection is most helpful and necessary when the individual members of the family differ most phenotypically and resemble each other more from their genetic make-up. If there is close resemblance within the family, the characteristics will be so highly heritable that individual selection for these characters will not be required. Large numbers within the family increase the value of family selection.

The effect of inbreeding is to increase the genetic resemblance within families and thus improve selection where phenotypic resemblance is small. Although crossing between inbred families may yield larger advances in one generation, the practical usefulness of inbreeding, merely to make family selection possible, is limited owing to the length of time required to establish the satisfactory inbred lines. It is quite possible that individual selection will give better results, as selection can be practised in each generation. Family selection is of great value with the all-or-none characteristics where heritability is necessarily small, as in breeding for disease resistance.

Purely family selection is almost as effective as combination selection when the inbreeding in the family is high and the phenotypic resemblance is low.

The combination method is at least equal to the other methods in all circumstances, but is most useful when phenotypic resemblance within the family is small and the genetic resemblance moderate, or when the phenotypic resemblance is large and the genetic resemblance much smaller.

Dairy Cattle

Comparative Rates of Production of Different Breeds of Dairy Cattle. Misner, E. G. *Fm. Econ.* (Ithaca, N.Y.), No. 156, 4024-8.

The production records for 1,616 herd sires were published by the American Dairy Herd Improvement Association for the year 1945. Yields of the daughters of these bulls were compared with the yields of their dams, after having been corrected for age, length of lactation and frequency of milking. It was found that the daughters' yields showed an average reduction of 178 lb. of milk, 2 lb. of fat and 32 therms of milk energy, but an increase of 0.05 per cent in fat.

Seven breeds were included and in six of them the daughters showed a decrease in milk production compared with their dams, the exception being the Red Dane breed. Three breeds—Holstein, Red Dane and Shorthorn—showed an improvement in yield of fat, whilst the remaining four—Ayrshire, Brown Swiss, Guernsey and Jersey—each showed a reduction of from 1 to 7 lb. The percentage of fat was consistently higher in the daughters' milk, the increase ranging from 0.05 to 0.16 per cent.

The author draws the conclusion that either the bulls are not good enough to improve their daughters' yields or too much emphasis is being placed on fat percentage. Consideration should also be given to the question of whether the conversion factors are the correct ones. It may be that the sire has had little influence on the differing yields of milk and butter fat shown between daughter and dam, as in subsequent lactations these same daughters may give higher yields with a lower fat percentage. These yields, when converted to maturity, may more nearly approach their dams' production. If the conversion factors used are correct, then it is apparent that animal breeders will need to employ better methods of developing and choosing their herd bulls.

It is suggested that records for dam and daughter comparison should be made at identical ages, with the same number of times of milking and under uniform environmental conditions, such as feeding, care and management.

The Pure Bred Dairy Cattle Association has computed standard score card weights for the different breeds ; if these weights are taken it will be found that for an increase in weight of 1 per cent in the live-weight amongst breeds, there is a corresponding increase of slightly more than 1 per cent in milk production. It is thought that milk production is more closely associated with the weight of the animal than are the fat and energy contents of the milk.

W.L.

ANIMAL NUTRITION

Nutrition of the Bacon Pig

The problem of the efficient utilization of the feedingstuffs available for livestock production is receiving ever-increasing attention from investigators and all those who are interested in increased production

of livestock products. Intensive research on bacon production is being pursued to establish the value of available feeds and their optimum levels for incorporation in rations to give maximum production without waste of protein.

Continuing earlier investigations at Cambridge, Woodman and Evans (*J. Agric. Sci.*, **35**, 3 (1945), 133) showed that the omission of a protein supplement at 90 lb. live weight caused the pigs to be slightly less thrifty over the period 90-150 lb. live weight. This was probably because the optimum quantity of protein for growth was not being supplied as in protein-supplemented rations. However, the results of the trials showed that a ration of cereals and weatings, with a small quantity of lucerne meal and supplemented with 7 per cent of white fish meal to 90 lb. live weight, supplied enough protein for optimum growth to finished weight without further protein supplement. The figures for daily live-weight increase and efficiency of food conversion compared favourably with those for pigs receiving 10 per cent of white fish meal to 150 lb., followed by 5 per cent of extracted soya bean meal to 200 lb. Carcasses of the pigs finished on a low protein diet were examined for quality, and the results showed that they did not differ significantly in conformation or leanness from animals fed on the standard protein diet.

The authors point out that considerable economies are possible in the use of fish meal or similar animal protein foods which are difficult to obtain at present. Woodman and Evans (*Ib.*, **38,** 3 (1948), 354) have supplemented their farm scale trials by a systematic study of the metabolism of proteins in pigs on standard rations of 10 per cent fish meal to 150 lb. live weight and 5 per cent of high vegetable protein at a later stage compared with fish meal at a 7 per cent level to 90 lb. and no high protein supplement thereafter. In these experiments all differences in mineral content of the meal mixtures were rectified by suitable additions of chalk and common salt, and the two treatments were comparable in respect of content of total digestible nutrients. The results showed that the high level of protein was unnecessarily generous, particularly over 90 lb. live weight, and that the feeding of 7 per cent of fish meal to 90-100 lb., followed by no protein supplement, allowed body protein to be deposited at a rate equal to that of the pigs on the standard fish meal ration. Further, the nitrogen balance figures showed that the protein of the low-protein diet was more efficiently utilized. The results in relation to mineral balance are also of interest. The authors showed that the mineral supplement added to the low-protein diet enabled phosphate to be stored efficiently from the ingested barley meal, indicating that pigs can utilize the phytic acid phosphorus of barley meal.

The value of available protein supplements for bacon production has also been investigated by Woodman and Evans (*Ib.*, **38,** 2 (1948), 200). Digestibility trials were carried out with pigs to gain more specific information concerning the value of such protein foods as whale meat meal, white fish meal, feeding meat meal, extracted ground nut meal, bean meal and dried yeast. Approximately 90 per cent of the organic matter present in these feeds, except bean meal, was found to be

digestible by pigs; with bean meal the digestibility was 78.7 per cent. The value of whale meat meal was found to depend on its protein content only, since the ash content of this meal is only of the order of 2 per cent. Approximately 7.25 per cent of whale meat meal was found to be equivalent to 10 per cent of white fish meal.

Earlier experiments at Cambridge carried out by the same authors (*Ib.*, **35,** 1 (1945), 44) were designed to establish the value of extracted palm kernel meal for pigs. These investigations showed that palm kernel meal contained 12.1 per cent of crude protein digestible by pigs and thus could not be regarded as a protein-rich food for pigs. Conclusions from feeding experiments showed that the meal was too fibrous for inclusion in the ration of newly-weaned pigs, but that after the pigs had attained a live weight of 100 lb. the percentage of palm kernel meal could be increased to 33 per cent.

Limited quantities of dried grass meal are becoming available for livestock feeding, so that information regarding its value as a feed for pigs is of interest. Investigations by Woodman and Evans (*Ib.*, **38,** 1 (1948), 51) using dried grass meal up to one-third of the ration have shown that feeding this quantity in the form of a thick slop in water can overcome the loss of muscular energy which is associated with consumption and mastication of such a bulky food. It was found that pigs fed on the high grass meal ration had a slightly lower carcass percentage and a thinner back fat.

A new approach to the attainment of more economical gains in bacon production has recently been made by some American workers in relation to the utilization of the major constituents of pig feeds. Recent research has shown that numerous compounds having antithyroid activity can be utilized to study the effects of lowered thyroid activity on growth and fattening in livestock. Preliminary work with pigs was carried out by Muhrer and Hogan (*Proc. Soc. Expt. Biol. Med.*, **60** (1945), 211) using thiouracil to depress thyroid activity. These authors claim that the addition of 0.2 per cent of thiouracil to the ration resulted in more rapid gains in weight. In these experiments, however, the gains of the untreated animals were low, due to the fact that their food consumption had to be reduced to that of the treated pigs. Later experiments conducted by McMillen *et al.* (*J. Anim. Sci.*, **6,** 3 (1947), 305), in which all pigs were fed *ad lib.* and the treated group received 0.1 per cent of thiouracil, showed that the treated group gained 0.16 lb. less per day but required 13.8 per cent less food per unit of gain. Different responses were recorded in two breeds. At the New Jersey Experimental Station, Noot, Reece and Skelly (*J. Anim. Sci.*, **7,** 1 (1948), 84) showed that the feeding of 0.25 per cent of thiouracil increased daily gains and reduced the amount of feed consumed, provided that the pig had attained the necessary skeletal development. Though the results of these experiments are interesting, it would appear that the experimental findings are not consistent, and further work will have to be carried out on the effects of antithyroid treatments on the animal before conclusions can be drawn.

R.G.B.

DAIRY HUSBANDRY

Housing of Dairy Cattle

In the last decade a number of studies of " chore practice," i.e., daily work routine, have been made in the United States. These studies have indicated that a great saving in labour can be made where buildings are properly arranged, especially as regards the internal lay-out of the cowhouse and its relation to the milk room and food store. Little reliable data has been available in this country until a recent publication by the Farm Economics Branch of the University of Cambridge (*Univ. Camb. Farm Econ. Branch Rpt.* 32 (1949)). From a preliminary survey of 140 dairy farms some very great differences in labour requirement per cow were recorded. Evidence was obtained to show that the large herd absorbs less labour than the small herd, the machine-milked herd less than the hand-milked herd, and the yard and parlour arrangement less than the machine-milked herd in the ordinary cowhouse. From a study of milking routines and cowhouse lay-out a substantial saving in distance walked is attributed to the siting of the milk room in the middle position as opposed to the end position in an ordinary cowhouse, and also to the double row arrangement of standings as opposed to the single row arrangement. In the yard and parlour system the advantage of an arrangement of yards all opening into a collecting pen immediately adjacent to the parlour is emphasized.

One or two American papers (e.g., Graves, R. R. *et al.*, *U.S.D.A. Circ.* 762 (Nov., 1947)) have recently referred to a system of " pen barns " for dairy cows. These are buildings with a central feeding passage with pens on each side each holding about four or six cows, the milking being done in a parlour or another barn specially equipped for the purpose. Some evidence is provided of increased production in pen barns resulting from the greater comfort to the cows compared with those lying on orthodox standings. Another adaptation of the yard and parlour system used for many years in the State of Washington is described by Smith *et al.* (*Washington A.E.S. Pop. Bull.* 190 (April, 1949)). A feeding passage with mangers each side is covered by a 40-ft. span roof ; it is open-sided and set in a large open yard with " lounging barns " on the perimeter of the yard.

Further much-needed information on cowhouse ventilation has been collected by Findlay (*J. Agric. Sci.*, **38** (1948), 425) at the West of Scotland Agricultural College. After extensive recording of air temperature, relative humidity, carbon dioxide concentration, atmospheric cooling power and movement of air, the atmospheric conditions in a cowhouse with a large cubic capacity per cow (1,248 cu. ft.) were shown to be usually superior to those of a cowhouse with a small cubic capacity per cow (567 cu. ft.). In the buildings investigated, ridge ventilation formed the outlets and the size of the outlet was shown to be of considerable importance ; the size of inlets appeared to affect atmospheric conditions significantly only when the outlets were closed. An adjustable ridge outlet allowing up to 144 sq. in. per cow seemed necessary.

A Study of Multiple Births in a Holstein-Friesian Herd. Pfau, K. O., Bartlett, J. W. and Shuart, C. E. *J. Dairy Sci.*, **31** (1948), 241.

Data covering a period of about 15 years from the New Jersey Agricultural Experiment Station herd lead to the conclusion that twinning is an undesirable character in dairy cattle and efforts should be made to reduce its appearance by proper breeding methods and selection. Definite disadvantages of twin births include: shortened gestation periods, great parturition difficulties with subsequent increases in retained placentae, decreased conception rate, lower breeding efficiency and increased sterility. Twinning appears to be controlled by heredity. It is rare in the first parturition, and generally occurs late in life. The effect of environment is of very minor importance.

Genetics of Cattle. Schrode, R. R. and Lush, J. L. *Advances in Genetics*, **1** (1947), 210.

This excellent up-to-date exposition on the genetics of cattle includes chapters on chromosome numbers, colour inheritance, horn inheritance, inheritance of lethal, sublethal, deleterious and undesirable factors, inheritance of dairy and beef qualities, inheritance of antigenic characters, aural abnormalities, twinning, birth weights, gestation length, vitality, effects of artificial insemination, inheritance in species crosses, inbreeding, cross-breeding and grading.

A study of a 200-acre Berkshire Dairy Farm on Plateau Gravel in relation to its Use of Machinery. *Farm Case Study No. 4, N.I.A.E.*, July, 1946.

Full details are given of the history, lay-out and organization of a 200-acre dairy farm situated on a poor soil. A form of ley farming was introduced in 1938 and the tillage area increased from 15 to 172 acres. The farm now supports 79 cattle, 32 being dairy cows. Valuable figures regarding implements and their utilization, horse and tractor work analysis and seasonal distribution, and implement capitalization are given.

Beneficial Effect and Economic Importance of using all Colostrum produced in Calf-raising. Kaeser, H. E. and Sutton, T. S. *J. Dairy Sc.*, **31** (1948), 523.

Seventy-six calves were divided into two groups at birth, all receiving colostrum for 3 days. One group then received Holstein milk and the other group colostrum whenever it happened to be available, in place of milk. The latter group made more rapid weight gains, did not scour, and maintained a higher level of blood plasma vitamin A. The economic importance of using all colostrum to save marketable milk is indicated.

Weather and Management Influence Calf Health. Pounden, W. D., Hibbs, J. W. and Krauss, W. E. *Far. and Home Res.*, (Ohio) **32** (1947), 203.

A survey of Jersey and Holstein calves in 3 herds showed that 23 out of 41 cases of diarrhoea occurred when the outside temperature suddenly dropped. Thirty-eight cases were observed to begin on Monday and Tuesday compared with 36 for the other days combined, indicating the influence of a change of routine, or a " week-end weakness ".

A.S.F.

POULTRY HUSBANDRY

Trap-nesting

The most frequent complaint made by the would-be pedigree poultry breeder concerns trap-nesting. Apart from the natural disinclination to take on a good deal of patient recording, labour difficulties may make the task appear too costly. In the U.S.A., short-period trapping has been practised for some time and is permitted under that country's official poultry stock improvement schemes. A recent study of the accuracy of short-term trapping has been reported by A. B. Godfrey in a paper entitled " Three-day-a-week-Trap-nesting," published by the U.S. Department of Agriculture, Agricultural Research Administration (B.A.I.), in October, 1948 (A.H.D. No. 121). Godfrey showed that with approximately 400 Rhode Island Reds and a similar number of White Leghorns, the average egg production was 198 and 197.5 for the Rhode Island Reds and 200.2 and 199 for the White Leghorns on the basis of daily and three-day-a-week trapping respectively. The weekly figures for the three-day-a-week trap-nesting were obtained by multiplying the three-day figure by $2\frac{1}{3}$. This work of Godfrey indicates that on a yearly basis limited trap-nesting appears to be as sound as daily trapping.

For the pedigree breeder who is working with family groups, Nordskog's paper on " Periodical Trap-nesting and Family Section for Egg Production " in *Poult. Sci.*, **27**, 6 (1948), 713-8, which also deals with trap-nesting, will be of considerable interest. Nordskog approaches the subject from the viewpoint of the degree of heritability and the size of the family, i.e. the number of full sisters being trapped. His argument is that when reducing the number of trapping days it is necessary to have regard both to the degree of heritability and the size of the family. He gives as an example a family of eight full sisters when the egg production heritability is assumed to be 5 per cent, i.e. an increase of 5 per cent is assumed for each successive generation. Trapping on a basis of four days a month would reduce breeding progress by 12 per cent. This could be offset by increasing the family to ten full sisters. Nordskog's conclusions are that little is gained in trapping families of full sisters more than eight in number more often than two days per week, and that the addition of one bird in the number of the family is about the equivalent of twelve additional trap-nesting days so far as breeding progress is concerned. It should be realized that the figure of 5 per cent heritability for egg production is usually accepted as the average figure. Clearly, if this figure were greater and of the order of 30 per cent or more, family selection would be little more advantageous than individual selection.

For some time turkey breeding in North America has been directed along the path of breeding a broad-breasted bird in which the ratio between weight gained and food consumed is not unfavourable when compared with the larger sized strains. This work has not been entirely successful. Some comments on the relationship of breast width and shank length by V. S. Asmundson are of much interest in considering the genetics of this problem. His paper entitled " Inherited Differences

in Weight and Conformation of Bronze Turkeys" (*Ib.*, 695-712) indicates the relative importance of length of keel, length of shank and width of breast. Asmundson concludes that selection for change in length of shank would result in change of weight, but that this would not follow if the basis of selection were length of keel and width of breast.

Many poultry breeders have strongly opposing views on egg weight and hatchability, and a paper by Skoglund, Tomhave and Mumford (*Ib.* 709-12) is extremely useful in that the data is obtained from some 30,000 eggs. The authors come to the conclusion that 2-2¼ oz. is the best weight for a high degree of hatching.

The use of deep litter and the employment of various agents to reduce moisture has created some comment amongst poultrymen in this country. Many fear that Britain's climate is too humid to allow the successful operation of a deep litter system. More recently the method has been called into question as a suitable system for rearing stock which is intended to be managed under free range conditions at maturity. The point at issue is whether birds reared under deep litter conditions with any drying or heating agents (e.g., lime or radiant heating) might not prove even moderately successful in resisting a low status of infection on range land over which poultry has been kept. Koutz gives an account of some aspects of the problem in a paper entitled " Immunity Studies in Avian Caecal Coccidiosis " (*Ib.*, 793-7). He adopts the view that hydrated lime in deep litter does not prevent the oocysts of *E. Tenella* (the agent of *caecal coccidiosis*) from sporulating and is no more effective than deep litter alone in preventing coccidiosis. He also gives his opinion that when on a deep litter with or without hydrated lime, all the birds in overcrowded contaminated pens fail to ingest enough oocysts concerned with the disease to build up sufficient resistance to enable them to withstand later and heavier attacks—particularly if in a different environment.

An article by D. C. Warren on " Shifts in Breed Popularity and Performance " in *Report of National Plans Conference*, 1948 (U.S. Department of Agriculture (B.A.I.), 81-5) casts an interesting light on poultrymen's likes in this matter. Warren points out that the Rhode Island Red has shown a greater decline in popularity during the last three years than any other breed in the U.S.A. He makes the further point that this decline in what is also the most popular breed in this country has taken place in spite of the fact that Rhodes have excelled over all other breeds in egg-laying contests. While Warren mentions the increasing interest taken in New Hampshires, he considers that the poultryman is becoming increasingly influenced in his choice by strain rather than breed. In discussing new breeds, Warren deals with the hybrid chicken. He suggests that the State Agencies should attempt to equal the interest taken by commercial undertakings in the manufacture of these new breeds, and considers that the stock answer of the advisory officer to the poultryman's inquiry about the best breeds to keep—" you will probably do best with the birds you like best "—is out of date. Warren considers that there should be a specific answer to such an enquiry and suggests that that answer lies with the hybrid chicken.

R.C.

CROPS AND PLANT BREEDING

Dormancy in Seeds

Resistance of cereals to sprouting at harvest can sometimes be so important that it becomes a primary aim in a breeding programme. Fuchs and Ziegenbein (*Züchter*, **19** (1948), 97-100) report briefly on a procedure they have adopted with oats and wheat to introduce selection for this character in the early generations from a cross. Ears or panicles from widely-spaced plants are brought into a greenhouse and sprayed with water. The time needed for all the grains to germinate is taken as a measure of resistance. Although resistance to sprouting is very subject to developmental and seasonal fluctuations, selection on this basis has succeeded in increasing the average resistance of populations. The method is stated to be subject to a number of errors and uncertainties and to need improvement.

Hard seeds in white sweet clover (*Melilotus alba*) are apt to be a nuisance, because they make it possible for the plant to establish itself as a weed, especially following a seed crop. It is encouraging, therefore, that White and Stevenson (*Sci. Agric.*, **28** (1948), 206-22) have found it possible to select lines with seeds as permeable as commercial scarified seed. Their work on selection and hybridization shows that permeability is inherited and can be combined with other useful characters like low coumarin content, and that it is closely associated with a defect in the seed coats causing brown, sunken, irregularly shaped spots on the seed coat. Incidentally they found that very high losses of seedlings in the soil occur before and just after emergence without evident association with permeability.

Hybrid Vigour

The utilization of hybrid vigour in maize depends partly on the relative ease with which a crop of 100 per cent crossed seed can be produced by "detasseling" (removing the separately produced pollen-producing flowers from the seed parent). With crop plants in which both pollen and seeds are produced by the same flowers, this is not possible on a commercial scale, but in a naturally cross-pollinated species a bulk of seed can be produced which is mostly of crossed origin. The question then arises whether the proportion of inbred seed, which may be produced by self-pollination or pollination by other plants of the same line, will seriously reduce the yield. Burton (*J. Amer. Soc. Agron.*, **40** (1948), 919) has tested this in pearl millet (*Pennisetum glaucum*), an annual forage grass. Comparing the forage yield from different mixtures of hybrid and inbred seed, he showed that when the crop was sown at about the density in the row (4 seeds per inch) found in commercial plantings, mixtures in which hybrid and inbred seed were in the proportions 100 : 0, 90 : 10 and 80 : 20 respectively all gave about 20 per cent more yield than pure inbred seed. As the density was reduced to a half and to a quarter of this rate, the mixtures began to show a decline in yield compared with pure hybrid seed. Evidently, in a dense stand the

hybrid seedlings compete so successfully with the inbreds that the former make a disproportionate contribution to the yield.

The interesting question whether hybrid vigour is ever unconsciously used by breeders of crops classed as self-pollinating is raised by Howard (*J. agric. Sci.*, **38** (1948), 332) as a result of his cytological studies of the Cambridge-bred oat variety *Picton*. In 30 plants studied in 1945, the percentage of pollen mother cells showing evidence of irregularity at meiosis ranged from 0 to 94.4. Progenies of some of these plants studied in 1946 showed a strong regression towards regularity. Discussing the economic significance of these irregularities, Howard shows how they might explain the off-types such as chlorotic plants and grass-clump plants which occur more frequently in *Picton* than in old varieties such as *Grey Winter*. He also suggests that the heterozygosity they probably produce may make *Picton* more adaptable and at the same time give it a certain degree of hybrid vigour. Wheat varieties have previously been shown to behave in this way and there is some possibility that we may have to revise our ideas of the breeding structure of self-pollinated crops, at least when they are polyploid species.

An Unusual Type of Hybrid

Hybrids with chromosomes derived entirely from one species and a cytoplasm from another are unusual, though by no means unknown. They have in fact been deliberately produced by geneticists to investigate inheritance through the cytoplasm, which is almost exclusively provided by the egg cell. The hybrid of this type studied by Lein (*Züchter*, **19** (1948), 101-8) presents two new features which give it an added interest. Not only is it a hybrid between two genera, but the plants involved are both economically important—wheat and rye. By repeated back-crossing of a fertile (amphidiploid) Russian wheat-rye hybrid with rye pollen the wheat chromosomes were completely eliminated, and plants were obtained with the fourteen chromosomes of rye and a cytoplasm derived from the original wheat parent. These plants were quite viable but were distinguished from normal rye by reduced growth, as shown in height and tillering, reduced fertility and by characteristic floral abnormalities. The last named took the form of varying degrees of transformation of anthers into pistil-like structures (reminiscent of the deformations noted in barley florets in recent years in this country) and of transformation of the lodicules into glume-like structures, leading to failure of the opening of the florets at flowering and therefore to cleistogamy. The alloplasmatic hybrids (as Lein calls them) do not appear to be of any immediate value, but may be of some use to rye breeders who are undertaking an inbreeding programme. Incidentally, Lein points out that inbreeding in these hybrids causes a further loss of vigour, despite the fact that their cytoplasm is derived from a self-fertilizing species—good evidence that inbreeding depression is at least partly under control of the chromosomes.

J.L.F.

VEGETABLE CROPS

Don't Trim Vegetable Transplants. Dempsey, Paul W. *Market Growers' Jour. U.S.A.*, **76,** 6 (1947), 34.

The cutting-back or entire removal of some of the leaves on vegetable plants at the time of transplanting is a common practice of some vegetable growers. Cabbage, cauliflower, celery, lettuce and other plants are often treated in this way. Several advantages are claimed, such as production of stockier plants, ease of handling, reduction of shock to the plants and quicker recovery. Experiments showed, however, that the more a plant was trimmed the slower it recovered, the longer it took to mature and the smaller was the yield. The removed leaves were rich in carbohydrates, which are necessary for the growth of the plant. (From *Biological Abstracts*, **22,** 2 (1948)).

La Fumure de l'Asperge (The Manuring of Asparagus). Depardon, L. and Buron, P. *Ann. Agron.* (Paris), **17,** 5, 667-73.

Experiments carried out over more than five years have shown that calcium nitrate, Ca $(NO_3)_2$, proved superior to other chemical fertilizers when applied at the rate of 44½ lb. nitrogen per acre, both for total yield and weight of single spears of asparagus. (From *Biological Abstracts*, **22,** 10 (1948)). J.P.

HERBAGE

The Intensive Production of Herbage for Crop Drying. Part I—A study of the productivity of two annual crops and two leys and their responses in yield and chemical composition to applications of nitrogenous manure. Holmes, W. *J. Agric. Sci.*, **38,** 4 (1948), 425-36.

The productivity under a system of cutting for drying of two annual crops (barley and vetches) and two leys (perennial ryegrass and cocksfoot) were compared. Each crop had four manurial treatments: (1) control, (2) one single dressing of 3½ cwt. per acre when the crop was established or in the spring, (3) two dressings of 1½ cwt. per acre at establishment or in the spring, and 2 cwt. per acre in late June, and (4) ¾ cwt. per acre when the crop was established or in the spring, and 1⅜ cwt. per acre in late June and in late July. All manurial treatments supplied 3½ cwt. of nitrogenous fertilizer per acre per annum.

The dry matter yield of both leys exceeded that of the annual crops in the year of sowing and the following year. Vetches yielded 2,500-3,000 lb. dry matter per acre of 28-30 per cent crude protein content in two cuts; barley 2,500-3,000 lb. dry matter per acre of 18-21 per cent crude protein in five to six cuts; leys yielded 4,000-5,000 lb. dry matter per acre of 15-18 per cent crude protein in four cuts in their seeding year and 5,000-6,000 lb. of 15-18 per cent crude protein in five cuts in the following year. The difference in the yields from ryegrass and cocksfoot was negligible, but the latter produced a higher proportion of its yield after June, particularly when nitrogen was applied to these cuts.

Nitrogenous manuring had no effect on the total yield of vetches or the distribution of growth. With barley there were positive responses to application of nitrogen, but the treatments had little effect on the distribution of yield. The leys in the year of sowing were dominantly Italian ryegrass. Cutting was not started until July but continued until October, and late applications of nitrogen improved yields in the autumn.

In the year following sowing, the contribution of Italian ryegrass was unimportant. The control plots in both the ryegrass and cocksfoot leys contained a high proportion of white clover (S.100). In the ryegrass ley, the highest yield and the most constant growth was obtained on the control plots ; nitrogenous manuring depressed both yield of dry matter and crude protein. With the cocksfoot ley, only nitrogenous treatment (3) had a positive influence on yield of dry matter and greatly increased the yield in July and August.

It is suggested that where lucerne is unreliable and rainfall adequate a crop drying programme could be based on ryegrass and cocksfoot leys, the former to provide the main bulk of material for drying in the early part of the season and the latter in July and August. Nitrogenous manures could increase the yield in spring and again in July-August by applications in March and June respectively. Supplies could be supplemented by leys in their seeding year cut in the late season, vetches as a catch crop in June-July, and barley cut in early season and thereafter left for grain harvest.

Tall Fescue Grass is Poison for Cattle. Cunningham, K. J. *N.Z. J. Agric.*, **77,** 5 (1948), 519.

Cattle are reported to be lamed as a result of grazing tall fescue, and parts or the whole of the feet may eventually fall off. If removed from fescue pasture as soon as lameness is observed, animals usually recover. In the past, lameness was believed to be caused by eating ergots, which frequently grow on tall fescue. This view is not upheld, as lameness on tall fescue pastures may occur at any time of the year and is reported to have been induced by feeding ergot-free fescue hay.

Recent Developments in Silage-making in Denmark. Steensberg, V. *Emp. J. exp. Agric.*, **16,** 63 (1948), 155-62.

Silage-making was not general in the 'thirties, but was increasing in extent. During the war years, there was rapid expansion. In 1946, 23 per cent of all farms in Denmark made silage ; it is especially popular on the larger farms. Pit silos are being abandoned in favour of concrete or wooden silos.

The experimental work on preservatives showed that the A.I.V. process was superior to molasses, formic acid or no treatment, in that losses of dry matter and protein were lowest. Crops used for ensiling include clover-grass, lucerne, beet tops and other forage crops.

Feeding and digestibility trials showed that without neutralization of the acid in A.I.V. silage there was a considerable increase of the thermal

energy of the animals, representing reduced feeding value. Neutralization with calcium carbonate reduced the loss, and neutralization with sodium carbonate was completely effective ; with the latter, however, digestibility was reduced, probably owing to its use in too large quantities.

Silage-making in the Netherlands. Dijkstra, N. D. *Emp. J. exp. Agric.*, **16,** 64 (1948), 231-6.

This is a short review of the principles involved in the ensiling methods investigated and practised in Holland. The warm fermentation process at temperatures of 54°-70°C., as practised in the Dutch clamp process, is inferior to cold fermentation regulated by the addition of acid or sugar. When using molasses, experiments showed that the addition of 4 per cent molasses is necessary—possibly 6 per cent unless the silo is watertight.

Mineral acid processes (A.I.V. and Defu) have been increasingly used in Holland, but neutralization of the acid is necessary before feeding. The use of formic acid, whey, skim milk and various proprietory preparations has not been successful. The Hardeland method of adding crushed sugar beet or potatoes to the ensiled crop is still in the experimental stage and may prove useful, but it will be costly.

T.E.W.

NUTRITION OF HORTICULTURAL CROPS

Composts and Mulches in Horticulture

Since the horticulturist is rarely able to make farmyard manure he must rely on either composted residues, green manures, or mulches to maintain the humus content of his soils. Organic matter has many functions, including the maintenance of structure, the conservation of water, and the supply of major nutrients and micronutrients. It has been suggested—and vehemently upheld in some quarters—that organics improve the quality of the edible produce. More often than not compost materials lock up more nitrogen than they supply. As for soil structure there is increasing evidence that organic matter will improve " crumb " formation if allowed to decompose on the surface of the soil instead of rotting down in a heap. In the following four papers some of these points are dealt with.

Soil Mulches, Moisture and Nitrates. Mooers, C. A., Washko, J. B. and Young, J. B. *Soil Sci.*, **66** (1948), 307-15.

This paper deals with results obtained over a period of three years with uncropped lysimeters containing two types of Tennessee soil, and the use of three kinds of mulch materials—wheat straw, legume hay and farmyard manure, each applied at the rate of 5 tons per acre, containing 38, 198 and 226 lb. of nitrogen respectively : mulches reduced evaporation in the first year, and to a less extent in the second year, but showed no effect in the third year. The straw mulch was superior to the others. However, the same mulch reduced the production of

nitrates in the percolate from 82 lb. of nitrogen (control) to 57 lb. Legume hay increased the figure to 177 lb. and F.Y.M. to 172. The authors believe that the effect of the straw mulch in depressing nitrate production was due to soluble derivatives leached out of the straw into the soil, and not to the exclusion of air supply.

Effect of Mulches on the Nutritive Value of Tomatoes. Holmes, A. D., Smith, C. T., Rogers, C. and Lachman, W. H. *Soil Sci.*, **65** (1948), 471-5.

An experiment lasting six years is described ; it was designed to investigate the quality of tomatoes in relation to three types of mulches—horse manure, rye straw, and shredded sugar cane stalks. In the sixth year, samples of ripe tomatoes were taken and analysed for water, total and soluble solids, total sugars, reduced ascorbic acid, carotene, major nutrients and micronutrients. The water, total solids, total sugars and ascorbic acid for the control and mulched plots were the same. However, the tomatoes from the mulched plots contained more soluble solids, carotene, and the minerals calcium, magnesium, phosphorus and potassium. The authors suggest that, so far as quality is concerned, the use of rye straw would be justified in practice.

Utilization of Nitrogen in Cropping Systems with and without Green Manures in the Greenhouse. Pinck, L. A., Allison, F. E. and Gaddy, V. L. *Soil Sci.*, **66,** 39-52.

In the four-year experiments described the authors attempt to answer the question : Should one give nitrogen to the green crop which is grown to supply organic matter when ploughed in, or should it be given to the growing cash crop ? The green crops consisted of rye or millet and the succeeding indicator crops were wheat or Sudan grass ; nitrogen was supplied in the form of urea. They found that the largest yields and highest recoveries of nitrogen in the crop were obtained where no green crop was turned under. In the absence of green crops, less than half of the added nitrogen was recovered by the indicator crops ; they show that the remainder was used to produce humus from the decaying roots. Soil analysis showed that the addition of nitrogen alone to the soil increased the quantity of soil carbon above any other treatment. The percentage of carbon remaining where green crops were grown was 21, and 37 without green crops. They indicate that the experiment proves that under certain soil and climatic conditions it is possible to maintain soil organic matter at a reasonable level by using fertilizer nitrogen on crops that produce large yields of dry matter and extensive root systems.

Availability of Nitrogen in Composts Prepared from Waste Materials. Bould, C. *Emp. J. exp. Agric.*, **16** (1948), 103-10.

This paper deals with laboratory and field experiments which were designed on a complementary basis. Tests for available nitrogen in mature straw-sludge and refuse-sludge composts indicate that it is not readily available compared with amounts found in such organic fertilizers as dried blood and meat-and-bone meal. Field experiments have

confirmed these tests, and greater yields were obtained when inorganic nitrogen was added as well as the composts. A Long Ashton field experiment designed to test the different organic manures (10 tons per acre), as affecting growth, yield, nutrition and vitamin C content of blackcurrants, shows that available nitrogen is less in compost and F.Y.M. than in sewage sludge and meat-and-bone meal and is inadequate for maintaining maximum growth. As the losses from mature composts of organic matter and nitrogen can be as high as 40 per cent, it is questioned whether composting is an efficient method of supplying humus to the soil. A pot experiment is described to test this point. Composts prepared from straw and sewage sludge were (*a*) added to the soil immediately after being mixed, and (*b*) added to the soil after being incubated under optimum conditions to effect decomposition. Identical yields of spinach beet (indicator plant) were obtained where the compost was added to the soil nine weeks before sowing and when the compost was incubated nine weeks before being incorporated in the soil. In field practice, where incubation goes on too long in the heap it can be assumed that the losses of nitrogen and organic matter are considerable and it is suggested that methods of adding undecomposed materials to the soil should be investigated.

W.P.

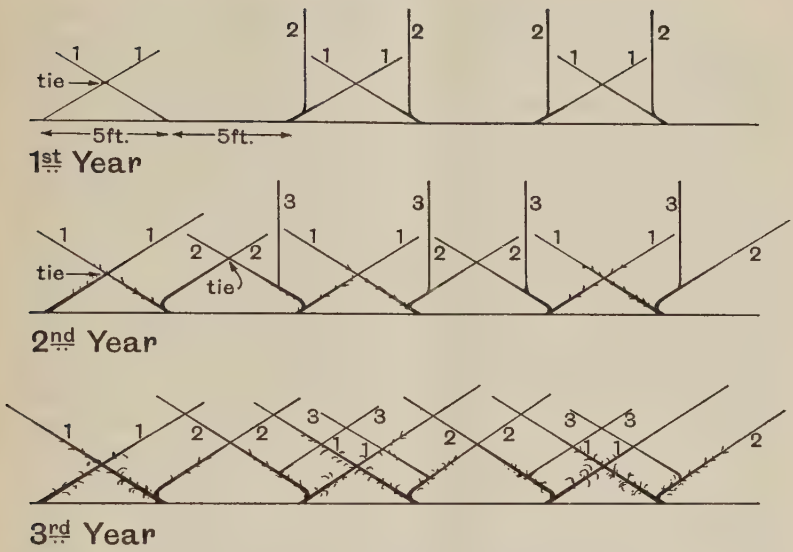
FRUIT

Intensive Apple and Pear Growing

The chief objections to the two methods of intensive apple and pear growing (cordon and dwarf pyramid) are the high initial cost of planting some 2-3,000 trees per acre and the heavy annual labour requirement for training and summer pruning.

In both France and Switzerland intensive systems continue to be popular and various modifications of the standard methods have been evolved. Thus the *arcure*, sometimes called the Lepage cordon, was devised, and shortly before the war experimental plantings on this system were made in England. The feature of the *arcure* is the successive bending over or arching of one-year-old shoots, first in one direction and then in the other, to build up a tier of arches until the desired height is reached. In the process all unwanted shoots are pinched back during the summer. The *arcure* can bring even vigorous varieties of apples and pears into early cropping, but it suffers from many of the disadvantages of the oblique cordon since it requires a supporting trellis and detailed care in training and pruning. The number of trees per acre is also high.

Recently a simplified method has been evolved by M. Bouché Thomas at Angers (Cornuz, L. A., *Rev. hort. Suisse*, **21** (1948), 250-3). This " fruit hedge " is claimed to avoid the recognized snags of the *arcure* and to save much labour. The rows are 8 feet (2½ metres) apart, with



Bouché Thomas "fruit hedge," showing (1) original maidens, (2) first-year water-shoots, and (3) second-year water-shoots.

strong maidens planted 4-8 feet apart in the row, according to the vigour of the variety and the rootstock (mainly M.I, M.II, M.III or M.XVI for apples, and quinces for pears) and the type of soil. The maidens are set at an angle of 30° to the ground, alternate ones pointing in the opposite direction along the row. Where the stems cross they are tied to keep them in position; no other support is needed. During the growing season a strong water-shoot coming from the base of each maiden is retained, all other vertical shoots nearby being severely pinched back. At the end of the season the water-shoot is inclined into the fruiting position (angle of 30° with ground) in the opposite direction to that of the original maiden. Where it crosses with the similarly treated water-shoot from the next tree along the row it is securely tied. The original maidens should now bear fruit buds and any side-shoots that have developed should be arched down to make them develop fruit buds. The following year a water-shoot is trained up from the base of the previous year's water-shoot, and eventually this is tied down to the fruiting position parallel with the original maiden. Where it crosses the other framework shoots it is tied, thus producing a hedge of crossing branches. All new growths on this framework are tied down in an arch to develop fruit buds. With most varieties three framework branches of this kind are sufficient, but a fourth may be formed with very strong varieties, making a total height of about 6 feet or a little less. In following years, the laterals are arched, superfluous ones being removed, and the tips of the framework branches are pruned back when they become too long. Too vigorous growth can be regulated by leaving another water-shoot on each tree to serve as a safety valve.

Great success is claimed for this method, which has the obvious advantages of needing fewer trees per acre (about 1,400 or less), no supporting trellis, and less labour for training and pruning than the usual intensive methods.

The arching method can be used on all forms of trained tree in place of summer pruning. Thus Paul Lécolier, (*Rev. hort. Paris*, **120** (1948), 267-9) describes how one- or two-year-old shoots quickly develop fruit buds when bent down. Instead of building up a framework of carefully trained branches, as in the espalier and the dwarf pyramid, he favours the bending over of all vigorous shoots to right or left, wherever they are, to bring about rapid cropping. This method he calls " à la diable." The shoots can be tied down to a very simple system of posts and wire, sufficiently strong to hold the shoots in position. The heavy cropping induced should be balanced by increased manuring and some reduction in the number of fruiting laterals may be necessary. Eventually some of the old fruiting branches may have to be replaced by new shoots. To obtain fruit of good size, it is advisable to thin out the fruit.

An alternative to arching for restricting growth and encouraging fruit bud formation is " brutting " (Hélye, D., *Rev. hort. Paris*, **120** (1948), 223-5). In July and August the young shoot, when just ripe, is broken half through or acutely bent (usually some four leaves from its base) with the result that the leaves in the part hanging down continue to function and pass food materials to the base, where fruit buds develop. The hanging part is removed during winter pruning. This treatment has two advantages over " pinching back " or summer pruning in that the total leaf area of the tree is not reduced and the secondary growth so often produced by the buds below a pruning cut do not occur. It is said to be suitable for pears, apples, quinces, peaches, apricots, plums, cherries, gooseberries and raspberries, but not for figs or, strangely enough, for nuts, though in this country the " brutting " of young shoots of cob-nuts is a regular practice.

" Brutting " might be especially valuable in parts of this country where a high rainfall renders summer pruning unsatisfactory.

H.B.S.M.

MYCOLOGY

Apple Scab (*Venturia inaequalis*)

Apple Scab is still one of the most important diseases to the fruit grower, and in recent years a number of papers have dealt with various aspects of the problem of controlling this disease, particularly the problem of obtaining washes at least as effective as, and less phytocidal than, lime sulphur.

Moore and Pierce [1] investigated the personal factor in routine spraying. They found that thorough spraying reduced the variability of infection of the leaves on the lower branches of treated trees, and possibly of the fruit also. They concluded that great variation from

tree to tree might, in some cases, be due to poor spraying. They also considered various practical and theoretical aspects of the problem.

Moore [2] has carried out a series of experiments in an attempt to improve the efficiency of fungicides commonly used for controlling Apple Scab. In the first he investigated the use of spreaders and found that if the sprays were put on at the right time with sufficient volume and pressure, control was not improved by a spreader. In one case spray damage was reduced when a spreader was used, but probably this was owing to the amount of deposit on the tree being reduced by an increase in the drainage from the tree. Improved results were obtained with colloidal sulphur when it was used with a spreader, but soap should not be used. A Bordeaux mixture at a strength of 2 : 3 : 100 was unsatisfactory because it caused damage, particularly on dessert varieties, the damage being increased by the addition of a spreader. Control was poor when light applications were used, but damage was reduced.

In a second paper, Moore [3] discusses the use of ferrous sulphate in an attempt to reduce damage caused by lime sulphur sprays. He found that the addition of this substance to a 1 in 60 lime sulphur post-blossom spray greatly reduced early leaf fall on *Cox's Orange Pippin* and *Worcester Pearmain*. Fruit drop was slightly reduced or postponed but was still severe. Zinc sulphate was less satisfactory than ferrous sulphate. In a combined wash, calcium-arsenate powder (0.4 per cent) caused more damage than lead arsenate paste (0.4 per cent) with a much lower As_2O_5 equivalent. Using lime sulphur at 1 in 100 the paste and colloidal form caused rather less injury than powder form (0.2 per cent) of twice the As_2O_5 equivalent. In this experiment most of the damage was caused by the second post-blossom application, and *Cox's Orange Pippin* was more susceptible to injury than *Worcester Pearmain*.

More recently Moore [4] has given a brief account of the use of undiluted lime sulphur in midsummer on five varieties of apples : *Lane's Prince Albert*, *Lord Derby*, *Cox's Orange Pippin*, *Worcester Pearmain* and *Bramley's Seedling*. When lime sulphur was applied as a spray the damage caused, though considerable, was much less than expected ; the author points out that the spray was applied with a low pressure hand pump in contrast to the high pressure equipment now generally used. When lime sulphur was applied as an atomized fog by a motor-driven compressor it caused no symptoms of injury on four varieties and only very slight symptoms on the leaves of *Lane's Prince Albert*. For purposes of comparison a $2\frac{1}{2}$ per cent lime sulphur was also applied to the trees with the hand sprayer and caused only slight damage. The author emphasizes that these results were obtained in only one trial and in one season, but that they indicate that it is worth carrying out further experiments.

Marsh [5] has given an account of results obtained by spraying fruit (including apples) for Apple Scab control with various new fungicides. He includes in the paper a review of the work of other authors (mainly abroad) with these newer substances, and gives a comprehensive bibliography. In his trials carried out at Long Ashton during the seasons

1944 to 1947 the following results were obtained on apples. In 1945, tetramethylthiuram disulphide and ferric dimethyldithiocarbamate were compared with lime sulphur. They gave poorer control of Apple Scab but caused no damage. The disadvantage of the ferric dimethyldithiocarbamate was that it left persistent and disfiguring spray residue. In 1946 and 1947 trials were made with sprays containing phenylmercurychloride. There was nothing to choose between these sprays and standard lime sulphur sprays, but the author points out that certain experimental preparations caused serious damage when applied as post-blossom sprays. Also in 1947 experiments were made comparing sprays containing hydroxyquinoline and heptadecylglyoxalidine preparations. The former substance did not appear to give any control for Apple Scab ; the latter, however, appeared to be as effective as lime sulphur and caused no damage to the sulphur-sensitive varieties *Stirling Castle* and *Lane's Prince Albert*.

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H.E.C.

ENTOMOLOGY

Potato Root Eelworm. Peters, B. G. *Agriculture*, **55** (1949), 493.

This paper is a most valuable summary of the history of the potato root eelworm problem from the time of the pest's discovery in 1881 up to the latest experiments with the chemical fumigant known as DD. The major areas in the country where this eelworm is a problem are listed. The various methods by which the nematode is spread are discussed, and the measures which have given some success in the treatment of seed potatoes for the killing of eelworms are described.

On the question of control by rotations, the importance of " groundkeepers " is stressed. Chemical control on a field scale is shown to be a most difficult problem which has been pursued actively for many years—it is stated that treatment of the top 8 inches of soil on one acre involves dealing with 1,000 cubic yards. The importance of distinguishing between stimulation of the plant—with frequently little or no actual killing of eelworms—and a genuine control of the pest, is emphasized.

A short account is given of recent trials with DD (dichloropropylene and dichloropropane). The results " fell far below earlier promise " ; though an increase in yield of nearly 50 per cent was obtained, this was to some extent offset by the fact that after growing a crop the eelworm population was slightly higher on the treated plots than on the controls.

Biological control methods for dealing with this pest are also discussed : for example, the stimulation of hatching of the eelworm larvae by various grasses, which are not themselves hosts of the eelworm. It is pointed out that such methods may be found to be a useful preparatory measure before fumigation treatment.

The rather fascinating possibility of using chemical substances to promote hatching is also touched upon, with special reference to the work in progress at Cambridge on the chemistry of the exudate from the roots of potato plants ; this, the substance that promotes hatching under ordinary field conditions, has been given the name " eclepic acid " by the Cambridge workers. The synthesis of this substance at an economic price is the most promising line of attack. The author, in summing up, says " The recent war has greatly intensified the problem, but although the present position is serious the outlook is not hopeless."

L.N.S.

VIROLOGY

The Relation between the Size of Fields and the Spread of Plant Disease into them. Part I. Crowd Diseases. Van der Plank, J. E. *Emp. J. exp. Agric.*, **16** (1948), 134-42.

The author defines a crowd disease as one which does not spread far and does not persist for long in the soil. He considers most virus diseases to be crowd diseases because their mode of dispersion is ineffective compared with spore-dispersed fungi and they do not persist long outside their host. An exception to this is the " Ratel " virus (mentioned later in these notes) which is soil-transmitted. The spread of crowd diseases is retarded by mixed cropping where the intermediate crop is immune, and by the isolation of fields and plantations.

The relation between isolation and the enlargement of fields is summarized in the theorem that if a disease entering a field can be controlled by isolation, it can also be controlled by making the fields larger and fewer. But both these methods of control are only applicable for diseases entering from outside ; there is little evidence that the increase in the size of a field affects the multiplication or spread of the disease inside the field.

Studies on the Importance and Control of Potato Virus X. Bawden, F. C., Kassanis, B. and Roberts, F. M. *Ann. appl. Biol.*, **35** (1948), 250-65.

The three methods of testing for potato virus X are by transmission to indicator plants, cross-immunity tests and serological methods.

Four different strains of virus X reduced the yield of *Majestic* and *Arran Banner* by 5 to 24 per cent. On the other hand, Scotch Stock Seed *Majestic*, infected with an avirulent strain of virus X, gave a better yield than the virus-free stock. These results seem to differ from those obtained in similar trials carried out in Australia and at Cambridge.

The authors suggest that other factors, in addition to freedom from virus, should be considered when selecting clonal lines for propagation. Transmission of the virus did not take place through the agency of the knife used to cut seed pieces, but infection can be spread from infected to healthy sprouts if the tubers are kept in the same sack. Under natural conditions, the spread of virus X is slow and can be avoided or much reduced if contact of the haulms is eliminated as far as possible. Infected volunteer plants surviving from previous crops are considered to be the chief danger to virus-free stocks.

Experiments on the Spread of Rugose Mosaic and Leaf-roll in Potato Crops in 1946. Broadbent, L. and Gregory, P. H. *Ann. appl. Biol.*, **35** (1948), 395-405.

A series of experiments on the spread of Potato Rugose Mosaic (virus Y) and Leaf-roll, which has been in progress on a uniform plan since 1943, was ended in 1946. Mean values for thirteen centres in England and Wales showed that in 1946, 69 per cent of the infections with virus Y and 48 per cent of those with Leaf-roll virus reached the tubers of *Majestic* potatoes by the beginning of August. Usually there was little subsequent increase of Rugose Mosaic, but a late increase of Leaf-roll was associated with a relatively high initial spread. Three-quarters of the virus Y and over half the Leaf-roll infections occurred within five plants distance of the source. There was no close correlation between the spread of either virus and the maximum number of *Myzus persicae*, either apterous forms on the plants or alate forms caught on adhesive traps, but centres with high trap catches in July and August showed pronounced late season spread of Leaf-roll. There were marked differences at different centres in the relative spread of the two viruses. The amount of spread and the gradients from source of infection of the two viruses are compared over the period 1943-46.

The Effect of Roguing on the Spread of Virus Diseases in Potatoes at Rothamsted in 1946. Gregory, P. H. *Ann. appl. Biol.*, **35** (1948), 406-11.

Experiments on roguing virus-diseased plants from plots of *Majestic* potatoes, which have been in progress since 1943, were continued in 1946. Plots were rogued in mid-June, early and late July, and plants were lifted from these plots at the end of July, August and September respectively. Roguing had little effect in reducing the spread of Rugose Mosaic (caused by potato virus Y). The spread of Leaf-roll was reduced to half that on unrogued plots by roguing on June 14. Later roguing did not reduce the spread of Leaf-roll unless combined with early lifting. Early lifting increased the effect of early roguing. In spite of these results, roguing maincrop potatoes in the south of England is not considered a practical control measure.

Methods of Recording Aphid Populations for Use in Research on Potato Virus Diseases. Broadbent, L. *Ann. appl. Biol.*, **35** (1948), 551-66.

Methods of counting aphids infecting potato crops are reviewed and discussed. The results of an aphis survey in different parts of England during 1946 and of counts at Rothamsted during 1947 are given and used to illustrate methods of expressing the counts ; the extent of virus spread in 1946 showed no close correlation with aphis numbers. It is concluded that an estimate of the number of aphids per plant is better for virus disease research than the number per 100 leaves. A method of estimating the number of aphides per plant with tolerable accuracy is described, but it is concluded that for most surveys a method which does not necessitate the counting of the aphids is adequate. Such a method, based on the percentage of leaves infested, is described.

Studies on the Virus of Turnip Yellow Mosaic. Markham, Roy and Smith, Kenneth M. *Parasitology*, **39** (1949), 330-42.

A new virus affecting turnips and related crops is described. The disease is characterized by a brilliant yellow mosaic and the insect vector in the field is one or more species of flea beetles. The virus is also transmitted by several other kinds of beetle and by such biting insects as earwigs and grasshoppers. This is the first record in Europe of a plant virus transmitted by a biting insect. The virus is sap-transmissible and crystallizes in small octahedra ; this is also the first time that an insect-borne virus has been crystallized. The virus in the plant has been found to consist of two parts, almost identical except that one part lacks nucleic acid. The part which lacks nucleic acid is non-infectious, and this offers direct evidence that nucleic acid is essential for multiplication of a plant virus.

Breeding Strawberries for Disease Resistance. Reid, R. D. *Agriculture*, **55** (1949), 476-82.

This is an account of the present situation as regards the breeding of strawberries for resistance to various troubles, especially root rots, virus diseases and bud eelworm. A good list of references is given.

K.M.S.

INSECTICIDES AND FUNGICIDES

A New Group of Insecticides

The list of chlorinated hydrocarbons now in commercial production as insecticides includes DDT and its relatives, dichlorodiphenyl dichloroethane (DDD or Rhothane) and dimethoxydiphenyl trichloroethane (Methoxychlor) ; BHC and the sulphurized product produced in France under the initials SPC (sulfure de polychloro-

cyclohexane); Chlordane (previously known as Velsicol 1068 or as Octaklor) and Toxaphene (a chlorinated camphene). To this list is now added Compound 118 as yet unchristened by the U.S. Department of Agriculture but described by the manufacturers (J. Hyman and Co.) as "a hexachlorodiendomethane-hexahydro naphthalene." A related oxygenated derivative (Compound 497) is said to be even more persistent than DDT. Tests of Compound 118, made at Long Ashton, show it to be of the same order of insecticidal potency as DDT; the lethal dose when fed to cabbage moth larvae is 0.14 ± 0.003 mg. per 0.5 grm. larvae, as against 0.06 ± 0.011 mg. with DDT. When used as a contact poison to the grain weevil, *Calandra granaria*, Compound 118 proved more slowly acting than DDT, which, after 68 hours was about 4.5 times as potent; but after 120 hours the median lethal dose of Compound 118 and of DDT were equal, and, after 140 hours Compound 118 had killed a higher proportion of the weevils than had DDT.

This difference in speed of action and differences in the reactions of the poisoned insects suggests that Compound 118 is dissimilar in mode of action to DDT. Moreover, Compound 118 is stable to alkali whereas DDT and the other chlorinated hydrocarbon insecticides are readily dehydrochlorinated by alkali—a reaction which Martin and Wain (*Nature*, **154** (1944), 512) suggested was indispensable for insecticidal action in these compounds. If this difference in mode of action is confirmed by further work, the new insecticide may prove of exceptional value for reasons which merit examination, since they largely justify academic work on the many new insecticides now being introduced.

Why, it has been asked, with potent insecticides like DDT and BHC available, should time be given to the examination of other insecticidal compounds which have been introduced, apparently, only for reasons of commercial competition? The answer lies in the danger that the widespread use of one insecticide or of insecticides similar in their modes of action will result in the unwanted selection of resistant strains of insect pest. As early as 1922, Quayle (*J. econ. Ent.*, **15** (1922), 400) reported that in at least two localities in California the red scale was no longer controlled by hydrocyanic acid fumigation; this development was traced by Woglum (*J. econ. Ent.*, **18** (1925), 593) to selective breeding. In S. Africa and the Argentine the repeated use of arsenical dips has lead to the evolution of an arsenic-resistant strain of the tick, *Boophilus Australis*; fortunately this pest is susceptible to BHC (Ault, C. N., *Nature*, **157** (1946), 699). From various sources come reports of house-flies resistant to DDT (e.g., Lindquist, A. W. and Wilson, H. G., *Science* (March 12, 1948), 276); these resistant insects are shown to be the offspring of flies surviving concentrations of the insecticide in normal use.

Variations in the resistance of individual insects of the same species to the action of an insecticide is a well-established phenomenon and is the basis of the probit bioassay. Theoretically, a complete kill is unattainable in an infinitely large population; in practice, the increase in insecticide concentration necessary to raise the kill from 99 to 99.9 per cent is usually so large that it is uneconomical. In some cases it is

possible that predatory insects will prevent the survivors of an incomplete insecticidal treatment from breeding further insecticide-resistant insects. Ripper (*Nature*, **153** (1944), 448) has used this method of biological control to supplement nicotine fumigation against aphis infestations. An alternative method is the use of a second insecticide different in mode of action to the first and to which the insects resistant to the first are susceptible; for example, cyanide fumigation against citrus scale insects could be alternated with petroleum oil sprays, since cyanide-resistant scales are susceptible to the oil treatment. The advisory officer has, therefore, good reason for recommending alternative control measures, and the arrival of suitable insecticidal compounds differing in mode of action from known insecticides is of fundamental interest.

Combined Insecticides. A logical conclusion to this argument is the combination of the two insecticides in one treatment. Plackett and Hewlett (*Ann. appl. Biol.*, **35** (1948), 347) has examined this problem from a statistical point of view. They consider a pair of insecticides A and B, which act independently and to which the resistances of the insects are completely and negatively correlated - that is to say, those insects which are more resistant to A are more susceptible to B, and *vice versa*. Given these conditions they show that a complete kill of the insects will be attained at a finite concentration of the mixture A + B. In a hypothetical case they calculated that, if a 99 per cent kill were obtained by 145 units of A alone or by 60 units of B alone, the whole population would be exterminated by a mixture of 10 units of A and 10 of B. There are, it is true, fundamental difficulties in finding a pair of compounds showing the required completely negative correlation. For instance, if both are contact insecticides, kill is dependent on a successful penetration of the compound to a sensitive biophase within the insect and it would not be easy to find compounds contrasted in their penetrative properties. But the combination of the two compounds might still be much more effective than either alone - an increased efficiency distinct from synergy - and this is a second reason for studying the properties of mixtures of insecticides.

H.M.

SOILS

Studies on *p*H Values of Sawdusts and Soil-Sawdust Mixtures. McCool, M. M. *Contrib. Boyce Thompson Institute*, **15**, 5 (1948), 279.

Sawdust has been considered at various times in the past as a possible source of organic matter for incorporation in soil, but it is usually rejected by horticulturists as having a deleterious action on soil fertility. Investigations by several people have shown that reduction in plant growth is caused by nitrogen deficiency, because the bacteria which break down the cellulose use for their own nutrition the nitrogen originally present in the soil. This drawback can be overcome by adding nitrogenous fertilizers, as is done in green manuring.

Examination of the *p*H values of sawdust from 19 different species of trees shows that there is a variation from 3.5 for cypress to 6.6 for hemlock. On the whole, conifers give lower *p*H values than deciduous trees. Sawdust from elm was about *p*H 6.0, and from oak about 5.7.

Leaching with water was found to increase the *p*H by about 0.6, i.e., to reduce the acidity. Mixtures of equal parts by volume of soil and sawdust, when stored for from a fortnight up to a year, were found to give *p*H values which were sometimes higher and sometimes lower than that of the original soil, and it is therefore advisable for *p*H determinations to be made on the mixtures before use.

Ordinary sawdust when mixed with 50 times its weight of soil reduces the rate of percolation of water through the mixture, but percolation is improved if the wood is in the form of shavings.

The implications of these observations are that sawdust may be useful as a source of organic matter for soils provided that before incorporation it is composted with soil and that decomposition is aided by the addition of nitrogen.

Activations of 2,4-D by Various Adjuvants. Hitchcock, A. E. and Zimmerman, P. W. *Contrib. Boyce Thompson Institute*, **15,** 4 (1948), 173.

It has long been known that the effectiveness of insecticides and fungicides is increased by the addition of substances such as wetters, spreaders, and stickers, and that the synergistic action of one useful toxic substance on another will provide a mixture whose effectiveness is greater than the sum of the effects of the components taken separately.

Hormones used either as weed-killers or for inducing root growth behave similarly, and experimental work has shown that mixtures of 2,4-D and contact herbicides, such as ammonium thiocyanate, sodium chloride, sodium bicarbonate and chlorinated-benzene compounds, were more lethal to plants than the individual compounds when used at the same rate, especially when wetting agents and spreaders were included. For instance, a mixture containing 0.32 per cent ammonium thiocyanate and 0.00001 per cent 2,4-D is more damaging to plants than 0.32 per cent ammonium thiocyanate alone. This concentration of 2,4-D is neither toxic nor inhibitive to the test plants when used alone.

It is suggested that more effective general purpose herbicides will contain more than one hormone, at least one toxicant, and wetters, spreaders, emulsifiers and stickers.

J.B.E.P.
W.M.D.

PROVINCIAL NOTES

NATIONAL GLASSHOUSE LETTUCE TRIALS

E. E. Skillman
Eastern Province

The National Glasshouse Lettuce trials carried out during the winter of 1947-48 covered six varieties in heated houses and seven in cold houses. This summarized report deals with the trials of the following varieties in heated houses : *Cheshunt Early Giant*, *Cheshunt 5B*, *May Queen*, *Early French Frame* (*Blackpool* strain), *Cheshunt Early Ball* and *Gotte à Forcer*. *Early French Frame* will here be referred to as "*Blackpool*." Seed of the six varieties was distributed to 21 centres in England, and the results from 17 centres are summarized. The seed of each variety came from the same source. The counties concerned in the trials were Devon, Dorset, Essex, Hertfordshire, Kent, Lancashire, Middlesex, Northumberland, Norfolk, Shropshire, Somerset, Worcestershire and Yorkshire.

The experiments were laid out in 6 × 6 Latin Squares except in Dorset and Northumberland, where Randomized Blocks were used ; at the Kent centre, a 7 × 7 Latin Square was laid out, the seventh variety being the grower's own selection. Records were kept of the type and dimensions of the house, the soil and its analysis, previous crops, and the quality, size, weight and general market characteristics of each variety.

Propagation and Planting

The seed was sown in boxes in October, in heat, and pricked off prior to planting. Soil and boxes were sterilized with formaldehyde, and about 14 days before planting the surface of the border soil in the houses was sterilized with 2 per cent formaldehyde at the rate of 1 gallon per square yard. Planting took place mainly in December, but in East Hertfordshire it was carried out in early November, and in Worcestershire as late as January 16. With a few exceptions the spacing was 9 × 10 inches.

Treatment

As far as possible the night temperature was maintained at 60°F. for the first fortnight, and 50°-55°F. thereafter. The crops were kept well watered and carefully ventilated throughout the whole season. To minimize losses by Botrytis, diseased leaves or plants were removed as they appeared, but gapping was discontinued two weeks after planting. Early attacks of aphis at the two Hertfordshire centres and at those in

Essex and Norfolk were checked by a nicotine spray. Botrytis disease occurred at ten centres, and in Somerset there were considerable losses from mildew (*Bremia*).

Cutting Dates

At most centres there were several cuttings before the crop was cleared. It is probable that at the few centres where there was only one cutting, some varieties were not fully mature ; this was the position in Essex with *Blackpool* and *May Queen*, and in Somerset with *May Queen*, *Early Giant*, and *Cheshunt 5B*. In Kent, *May Queen* was cut before maturity as the houses had to be cleared, and similarly at a Hertfordshire centre where the variety was being attacked by Botrytis.

Marketable Plant Number and Weight

The grading was I (24 pack, 6-8 oz.), II (30 pack, 4-6 oz.), III (36 pack, under 4 oz.) and Unmarketable. At some centres there was a 48 pack, mainly for the immature *May Queen*. The standard error per plot was low in all experiments except one.

At eight centres *Gotte à Forcer* had one of the lowest numbers of marketable plants, and on average it yielded the lowest number of marketable lettuce (60,300 per acre). *May Queen* produced the lowest number of marketable lettuce at three centres and the highest at seven centres, the difference between the figures for this and for other varieties being quite marked. There was little difference between *Cheshunt Early Giant* and *Cheshunt 5B*, with 62,500 and 62,400 per acre respectively. On the whole, *Cheshunt Early Ball* did less well than these two, but it did better on the heavy soils and at the mid-Hertfordshire centre was significantly higher in number than *Cheshunt Early Giant*.

Figures for weight of marketable produce in tons per acre of actual growing space show that *Early Giant* (8.53 tons) was the best of the Cheshunt varieties, with *5B* (8.01 tons) a close second, and after *May Queen* (8.61 tons) these varieties gave the highest yield over all centres. At eight centres the yield of *Early Ball* was significantly below that of the other Cheshunt varieties ; at the mid-Hertfordshire centre, however, it did better than any other variety except *Blackpool*, this being due to the higher number of marketable plants. On the whole, *Gotte à Forcer* yielded worst (6.02 tons), owing partly to its low resistance to disease but mainly to its being a smaller plant. It is hoped to repeat some of these experiments with variable spacing according to the size of the lettuce, and under such conditions *Gotte à Forcer* should make a better showing. *May Queen* yielded well, except where it was cut before maturity. On the medium soils *Blackpool* did badly, with yields comparable to those of *Gotte à Forcer*, but at other centres it was about average.

The proportion of the crop in the various grades was estimated for each variety, and the index of percentages again shows up the small size of *Gotte à Forcer*. On the whole, *Cheshunt Early Giant* did best

under the method of marking used, but at several centres *Cheshunt 5B* did as well or better. On the heavy soils *Cheshunt Early Ball* ranked highest.

Market Qualities

Near the time of cutting, marks were given for earliness, overall size, size and firmness of heart, leaf texture and size of core. For earliness, *Cheshunt 5B* led at all centres except Somerset, where *Blackpool* was the earliest, followed by *Cheshunt Early Giant* and *Cheshunt Early Ball.* There was little difference between *Blackpool* and *Gotte à Forcer*, which were the next to mature ; *May Queen* was by far the latest. *May Queen* was the largest lettuce at almost every centre, and *Gotte à Forcer* the smallest. Of the others, *Cheshunt Early Giant* was the largest, but there was little difference between the others.

In general, the Cheshunt varieties appear to have the best market qualities, *Early Giant* and *5B* being the best, with *Early Ball* third. *Blackpool* was variable in quality, and *Gotte à Forcer* and *May Queen* were well below the other varieties. *Gotte à Forcer* was at a disadvantage owing to its small size, and *May Queen* lost points because of its slowness in maturing and poor hearting. There are indications, however, that under exceptionally good light conditions *May Queen* matures earlier than under poor light conditions, in comparison with the " short day " Cheshunt varieties.

Disease Resistance

Despite precautions, there was a considerable amount of Botrytis. Results show large variation in losses from centre to centre, but generally *May Queen* was the least affected and *Gotte à Forcer* the worst. Of the Cheshunt varieties, *5B* was least affected by Botrytis. At the Somerset centre, the crop was severely infected by mildew.

Conclusions

Throughout the series of experiments the Cheshunt varieties proved to be the most satisfactory. There was little difference between *Early Giant* and *5B* ; the former was perhaps slightly better as regards size, while the latter was a little earlier in maturing. *Cheshunt Early Ball* was a smaller lettuce, although it hearted well, and it appeared to be a little more susceptible to disease than the other two.

Blackpool was a good variety generally, but its quality and size varied from centre to centre. It appeared to do least well at the nurseries with medium soils, but this may well be due to factors other than soil type. It was a little later in maturing than the Cheshunt varieties, and was not very firm in the heart.

May Queen was a large, loose lettuce, and much later than other varieties in maturing. Although the yield by weight of marketable produce was high, the hearts were small. *May Queen* had the advantage of suffering less from disease than the other varieties.

Gotte à Forcer could well have been planted more closely, for it was a much smaller lettuce than the rest. Its hearts, although small compared with those of other varieties, were firm. The losses due to Botrytis were high, but the number of lettuces unmarketable because of small size was not great. The majority were in Grades II and III, and the average weight per head was 3.45 oz. Planted more closely the crop might have been comparable with that of *Cheshunt Early Ball.*

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